A novel implementation framework for ISO 9001:2015

by
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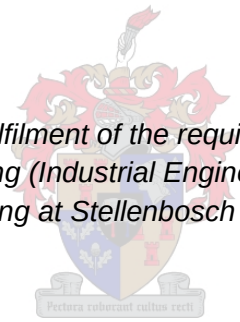

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Supervisor: Dr WA van Dyk

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated), and that I have not previously, in its entirety or in part, submitted it for obtaining any qualification.

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Abstract

This study proposes an alternative implementation method for ISO 9001:2015 by using knowledge transfer best practice as a basis for the development of an implementation framework. ISO 9001 is by far the most widely implemented ISO management system standard with an implementation base of 1.1 million accreditations worldwide, and the benefits of ISO 9001 accreditation are well established. Despite this, implementation of the standard is at times superficial. Unfortunately, there is a gap in literature on implementation methods for ISO 9001. This study will, therefore, be a valuable contribution to the ISO 9001 body of knowledge. Organisations seeking or maintaining an ISO 9001:2015 accreditation would find the proposed framework useful.

Implementations are usually done by means of a checklist gap assessment and action plan. However, this is consistent with presenting requirements in paragraph form and is not in line with knowledge transfer best practice. It has been shown that diagrams can assist with learning. Although the environments are very different, organizational learning, and therefore the ability to implement ISO 9001 requirements, might also be more effective if the requirements are presented in a diagram or flowchart form. This principle was applied in the development of an alternative implementation framework, namely the Quality Framework, which is in the form of an interactive and editable flowchart. This approach promotes the sustainable integration of requirements into existing operations.

The Quality Framework is novel in that it provides a consolidated framework of the generic requirements of the standard in a diagrammatic format that is interactive and allows managers to populate with particulars from their own environments.

To test the impact of the framework, the attitude of managers towards ISO 9001 was selected as a metric and measured by means of a six-point Likert style survey. The framework was tested within a South African State-Owned Enterprise. Significance tests provided the following insights in favour of the framework when compared to the commonly used checklist method. The framework is superior in providing operational improvement methodologies and potentially has a positive effect on how managers perceive their operations. In addition, it is potentially less effort to maintain than the checklist.

The sample size for each survey group was 17 and 19 respectively. Despite the small sample size, the endeavour involved targeting 65 departments in the participating organisation with 38 of them responding to the survey. This constitutes a big organisational undertaking. In light of these conclusions, it is recommended that the Quality Framework be used for the implementation of ISO 9001:2015.

Opsomming

Die navorsingstudie stel ’n alternatiewe metode vir die implementering van ISO 9001:2015 voor, deur die ontwikkeling van ’n implementeringsraamwerk wat geskoei is op beste praktyk met betrekking tot die beginsels van kennisoordrag. ISO 9001 is verreweg die mees algemene geïmplementeerde ISO bestuurstelsel standaard, met 1.1 miljoen akkreditasies wêreldwyd. Die voordele wat ’n ISO 9001 implementering inhou is goed gevestig. Ondanks daarvan is die implementering van die standaard steeds soms oppervlakkig. Ongelukkig bestaan daar weinig akademiese literatuur wat handel oor die implementeringsmetodes vir ISO 9001. Hierdie studie sal dus ’n waardevolle bydrae maak tot die ISO 9001 akademiese literatuur. Organisasies wat beplan om ’n ISO 9001:2015 akkreditasie te bekom of te onderhou, sal die voorgestelde raamwerk waardevol vind.

Die implementering van ISO 9001 word oor die algemeen voltooi deur die opstel van ’n kontrolelys wat tekortkominge identifiseer en ’n aksieplan om die tekortkomige aan te spreek. Hierdie metode is egter soortgelyk daaraan om die vereistes in die vorm van ’n paragraaf voor te stel en is nie noodwendig die beste praktyk vir kennisoordrag nie. Studies het aangedui dat die gebruik van diagramme bydra tot voorbereiding vir toetse. Alhoewel die omgewings wesenlik verskil, kan die voorstel om ISO 9001-vereistes as ’n diagram of vloeidiagram uit te beeld dus ’n effektiewe metode wees om die vereistes oor te dra. Hierdie beginsel is gebruik tydens die ontwikkeling van ’n alternatiewe raamwerk vir implementering, naamlik die Kwaliteit Raamwerk. Die raamwerk maak gebruik van interaktiewe vloeidiagramme wat deur die gebruikers ingevul en gewysig kan word. Die benadering bevorder die volhoubare integrasie van die ISO 9001-vereistes in bestaande besigheidsprosesse.

Die Kwaliteit Raamwerk kan beskou word as nuut en uniek aangesien dit ’n gekonsolideerde raamwerk van die generiese vereistes van die ISO 9001-standaard in ’n interaktiewe diagram aan bestuurders verskaf. Dit laat bestuurders ook toe om inligting uit hul eie omgewings tot die raamwerk by te voeg.

Die impak van die Kwaliteit Raamwerk is bepaal deur ’n meningsopname waarin die ingesteldheid van bestuurders teenoor die implementering van ISO 9001 gemeet is. Die bestuurders se ingesteldheid is gemeet deur gebruik te maak van ’n ses-punt Likert-skaal vraelys. Die raamwerk is daarna getoets in ’n Suid Afrikaanse staatsbeheerde instelling. Die verwerking van die data is voltooi deur gebruik te maak van statistiese toetse. Die resultate het getoon dat die respondente die raamwerk bo die tradisionele kontrolelys verkies. Die raamwerk word ook as ’n beter opsie beskou om operasionele verbeteringsprosesse te fasiliteer. Dit het waarskynlik ’n positiewe invloed op die bestuurders se uitkyk op hul operasionele omgewing. Verder vereis die raamwerk waarskynlik minder onderhoud in vergelyking met die kontrolelys.

Die steekproefgrootte vir die opname was 17 en 19 onderskeidelik. Ten spyte van die klein steekproefgrootte het die onderneming 65 departemente van die deelnemende organisasie geteiken, waarvan 38 op die opname gereageer het. Die loodsstudie kan dus gesien word as ’n groot onderneming. Met betrekking tot die gevolgtrekkings van die studie, kan aanbeveel word dat die Kwaliteit Raamwerk as voorkeur vir die implimentering van ISO 9001:2015 gebruik word.

Acknowledgements

I would not have been able to do this project on my own had it not been for the dedicated structure of individuals that supported me through this process. Firstly, I would like to thank my supervisor, Dr Wynand van Dyk. I could always tap into his wealth of knowledge when I was at a crossroad. Thank you for embracing my vision for this project and coming along for the ride. Next, I would like to thank my Manager at work, Rustum Emjedi, for the whole-hearted support for the entire duration of my studies and for always inspiring our team to always push innovation in everything that we do. To my brother, Darius Becker, who was my library partner and worked long hours along with me. To my parents, that brought me up to be the person that I am today. Then, last but not least I would like to thank Andre Smit, for his unwavering support throughout this time. You are my rock. You were always willing to listen and discuss in the greatest detail to all the trials and tribulations of this project. I was lucky to have someone so close that could advise me every step of the way. I greatly appreciate all the energy you put into supporting me on this journey.

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Glossary

Acronyms and Abbreviations

ISO	International Organization of Standardization
QMS	Quality Management System

Nomenclature

Symbol	Description	Units
η	Median	-
μ	Mean	-
H_0	Null Hypothesis	-
H_1	Alternative Hypothesis	-

Chapter 1

Introduction

In this Chapter, a brief overview of ISO 9001 and implementations considerations will be given. This sets the context for this research study. Following this, the key principles that served as a basis for the development of the research problem and objectives will be discussed. This is followed by an overview of the research methodology followed in this study. Finally, the overall structure of this document is set out and discussed.

1.1. ISO 9001 Quality Management System standard

ISO 9001 is by far the most widely implemented standard from the International Organisation of Standardisation's (ISO) management system standard series (The ISO Survey of Management System Standard Certifications, 2016). ISO 9001:2015 is the latest revision of the standard on Quality Management Systems (QMS) and sets requirements with regards to the following principles (Quality Management Principles, 2015):

- Customer focus
- Leadership
- Engagement of people
- Process approach
- Improvement
- Evidence-based decision making
- Relationship management

In addition to the wide implementation base, there is well-established research that found significant benefits can be derived from an ISO 9001 certification (Rusjan & Alič, 2010). Despite this, there are many challenges involved in implementing a QMS that is sustainable and well-integrated into an organisation's operations. Sustainable implementation of a QMS refers to a system that is integrated into the operations of an organisation so as to provide value to the organisation and that will continue to do so in future.

This is supported by studies that show that superficial implementation of the standard is common among certified companies in China (Zeng, Tian, & Tam, 2007). In addition to this, Biazzo (2005) found cases of "ceremonial conformity" prevalent in the audit phase of implementation initiatives.

In light of the challenges associated with implementing ISO 9001, consider the aspects discussed below.

Allur, Heras-Saizarbitoria & Casadesús (2014) found that if better internalisation of the standard's requirements can be achieved, more organisational value can be derived from an ISO 9001 certification. In addition, studies have found that presenting information in diagram format is superior as opposed to information in paragraph format (Ainsworth & Loizou 2003). This constitutes knowledge transfer best practice. This effect is further enhanced if the diagram is in an interactive multimedia format (Ollerenshaw, Aidman and Kidd, 1997).

Current implementation methods involve the use of a Gap Assessment Checklist, where departments are assessed against the Checklist to determine their level of compliance. Gaps are addressed by means of an action plan. However, presenting the requirements of the standard in this format is consistent with presenting info in paragraph format and it may, therefore, be asserted that this is not the best way to communicate ISO 9001 requirements.

Since there are known implementation issues associated with ISO 9001 certifications and because of the wide implementation base, finding a more effective means of integrating ISO 9001 sustainably into an organisation's operations, can have far-reaching effects. Benefits of and barriers to ISO 9001 implementation are well documented in literature. However, there are gaps in literature on how to overcome these barriers.

1.2. Research Question and Objectives

Findings by Allur et al. (2014) on the internalisation of requirements in addition to findings by Ainsworth & Loizou (2003) and (Ollerenshaw, Aidman and Kidd, 1997) on knowledge transfer best practice were used as key principles for this study. These findings serve as a basis to explore ways to improve current implementation methods.

A novel implementation method is proposed where the requirements for ISO 9001:2015 are presented in flowchart format, for leadership to populate with information from their own environment. This is as opposed to traditional implementation methods where requirements are presented in a checklist format for leadership/consultants to implement.

Yeung, Lee & Chan (2003) found that leadership's "attitude" and "understanding" are key aspects for the successful implementation of ISO 9001. Therefore, managers' attitude toward ISO 9001 was selected as a metric to measure the success of the proposed implementation framework.

In light of these considerations the associated research question for this study is as follows:

> Can implementation of ISO 9001:2015 requirements be facilitated better through the utilisation of a flowchart implementation framework?

In order to answer the research question the following objectives have been set:

1. Develop a novel implementation framework for ISO 9001:2015 by presenting requirements in an editable flowchart format.
2. Determine the effect of the novel implementation framework on manager's perception and attitude towards ISO 9001:2015 in comparison to the effect of the checklist implementation method.

1.3. Research methodology

A brief overview, together with the route map followed as part of the research methodology (Figure 1), is provided in this Section of the Chapter.

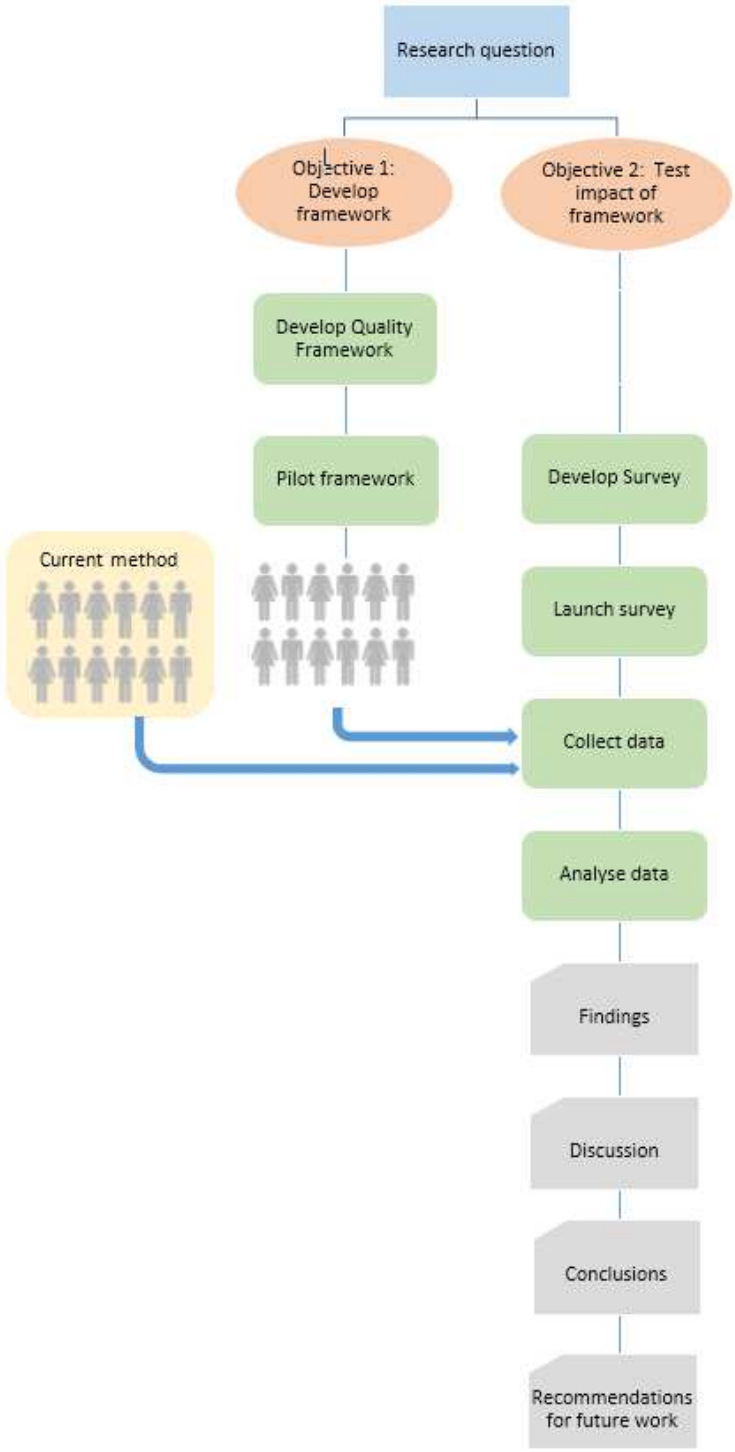

Figure 1: Route map of research process followed.

Table 1 provides a breakdown of each step of the research methodology as set out in Figure 1 and in which chapter it is covered.

Table 1: Research methodology and chapter breakdown

Objective 1 Develop a novel implementation framework for ISO 9001:2015 by presenting requirements in an editable flowchart format.		**Objective 2** Determine the effect of the novel implementation framework on manager's perception and attitude towards ISO 9001:2015 in comparison to the effect of the checklist implementation method.	
Develop Framework	**Chapter 3:** ISO 9001:2015 Implementation framework development Subsection 3.1 to 3.6	**Develop Survey**	**Chapter 4:** Survey development Subsection 4.1 to 4.3
Pilot Framework	**Chapter 3:** ISO 9001:2015 Implementation Framework development Subsection 3.7	**Launch Survey**	**Chapter 4:** Survey development Subsection 4.4
		Collect data	**Chapter 4:** Survey development Subsection 4.4
		Analyse data	**Chapter 5:** Data analysis method Chapter 6: Results Subsection 6.1 to 6.2.1
		Findings and discussion	**Chapter 6:** Results Subsection 6.2.2-6.2.3
		Conclusions	**Chapter 7:** Conclusions and recommendations Subsection 7.1 to 7.2
		Recommendations for future work	**Chapter 7:** Conclusions and recommendations Subsection 7.3

As shown in Figure 1 and Table 1, in order to achieve the first objective, the Quality Framework was developed by making use of key principles found in literature. Once the development of Quality Framework was completed, it was piloted at a South African State-Owned Enterprise (SOE). A sample of 25 departments was made available for the pilot. The remainder of the organisation uses the current Checklist implementation method.

Next, as illustrated in Figure 1, the actions taken so as to achieve Objective 2, and how they link to actions taken as part of meeting Objective 1, will be discussed. A survey was developed to determine what the effect is of the implementation method used on managers' attitude towards ISO 9001:2015. The survey questions incorporated a six-point Likert scale. Literature was reviewed as part of the development of the survey questions so as to ensure that the survey questions achieve the aim of establishing managers' attitude toward ISO 9001 as accurately as possible.

The survey was deployed to two groups of managers. The first group is the managers of the departments that participated in the pilot of the Quality Framework. The second is the group of managers of 40 departments that used the existing Checklist implementation method.

Once the survey data had been collected, an analysis was done in order to determine if there is a difference in attitude between the sample groups. Two types of significance tests were applied as part of this analysis, the Mann-Whitney and the Two-sample t-test. The results from these tests were reviewed and subsequently, findings with regards to the results were made. From these findings, conclusions were drawn and recommendations were made for future study.

1.4. Framework pilot study context

The framework developed as part of this study was piloted within a South African (SA) SOE. The organisation in question is of considerable size with around 40 000 employees. This organisation received its first ISO 9001 certification in 2013. This certification was for the current revision of the standard at that time, ISO 9001:2008. A transition project was initiated at the start of 2018 to move to the new revision of the standard, ISO 9001:2015.

As mentioned before, a sample of 25 departments was made available for the pilot. The rest of the organisation uses the checklist implementation method. So as to be able to test

the effect of the Quality Framework a sample of 40 departments that use the checklist method was made available to be surveyed as part of this study. This sample of 40 departments was used as a benchmark to compare the survey results of the pilot departments to. This study will benefit the participating organisation by providing insights into the method currently used to implement ISO 9001:2015 and also in terms of how improvements to this method can be made

From a South African point of view, there is still a lack of literature on ISO 9001 within both the public and the private sector. This is despite a growing number of ISO 9001 accreditations, with one in every four companies holding an ISO 9001 accreditation when last measured in 2016. This study is therefore particularly relevant for this context. However, the framework is generic in nature and can be applied to any industry and size of business. Therefore, all organisations seeking and maintaining accreditations stand to benefit from this research.

1.5. Document Structure

Figure 2 provides the structure that will be followed throughout the rest of in this document.

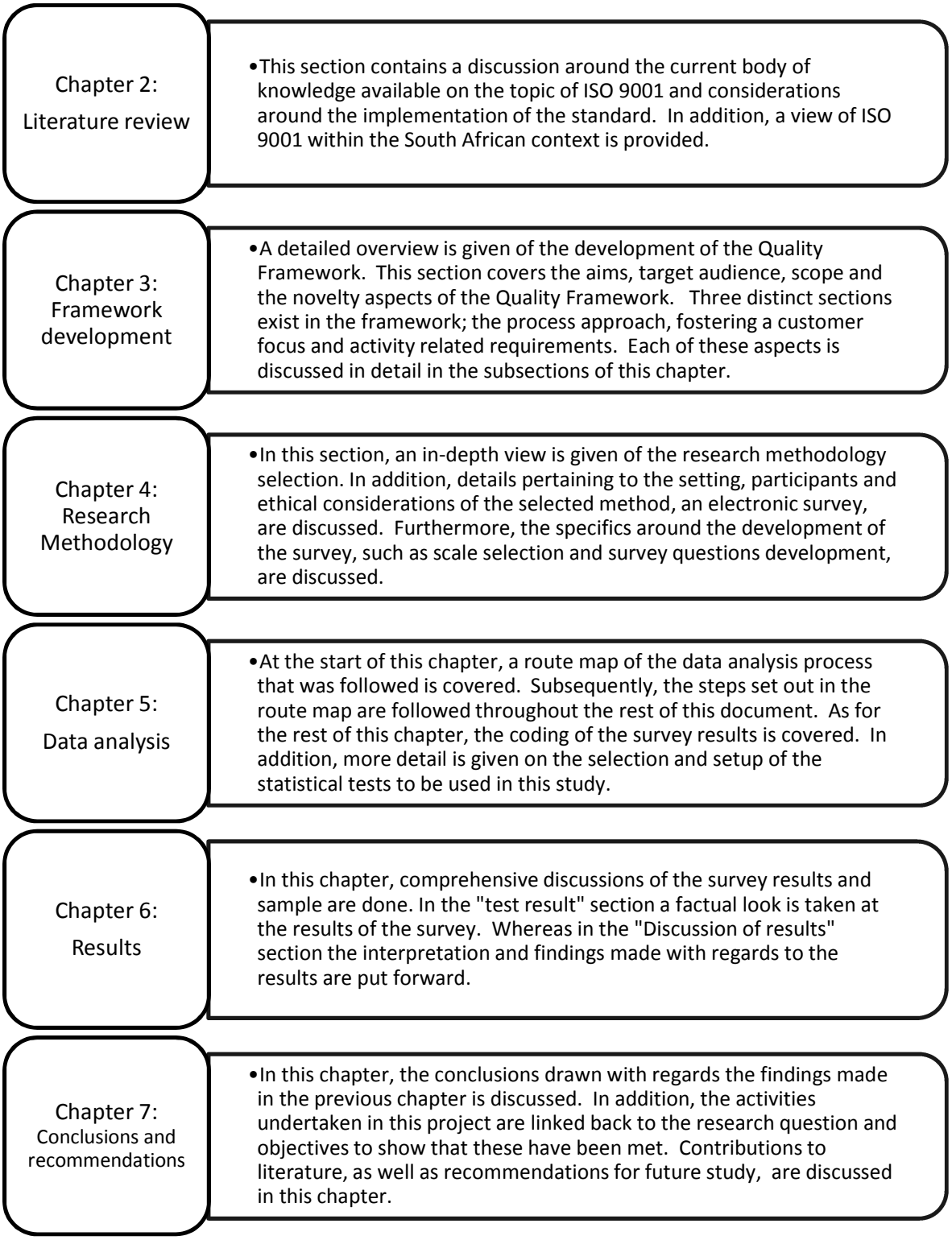

Figure 2: Document structure

Chapter 2

Theory and literature analysis

In order to set the context for this research project, a thorough review of the current body of knowledge on the topic was performed. A narrative literature review strategy was followed for this study and this Chapter gives an overview of what was found in literature and how this applies to this research project. Topics covered are the literature review strategy selection, ISO 9001 background including a breakdown of certification number worldwide and in South Africa in addition to implementation considerations. Subsequently, the research question and objectives will be defined and background information about the participating organisation will be provided.

2.1. Selection of review strategy

In order to select an appropriate literature review strategy, the planned research methodology (as set out in Figure 1) was considered. In addition, the guidance found in literature on the topic of literature review types and their applications were also taken into account.

Jesson, Matheson & Lacey (2011) provides guidance on different literature review types. In their discussion they recommend that a literature review type should be selected on a case by case basis depending on what is appropriate per individual research projects.

A narrative or traditional literature review strategy refers to the review of the current body of knowledge that sets the context and pertains to the research topic. This is as opposed to a systematic review of literature, which involves a systematic method for reviewing large literature repositories in order to contribute to answering questions on using findings from previous studies (Jesson et al., 2011). Hulley, Cummings, Browner, Grady & Newman (2011) also describes a systematic review as a strategy followed with the aim of answering a research question by the systematic and structured review of multiple previous studies.

As set out in the research methodology in Section 1.3 for this study, primary data will be produced and analysed in order to answer the research question. Therefore, a narrative

or traditional literature review strategy was selected as the approach for this study, since answering the research question is not dependant on secondary data, in the form of findings from previous studies. Since primary data will be used as the mechanism for answering the research question, in the case of this study the purpose of the literature review is to set the context of what is known in current body of knowledge. Therefore, it is argued that a traditional or narrative literature review strategy is appropriate since this type of review is concerned with setting the context rather than answering the question as in the case of a systematic literature review.

2.2. ISO 9001 background

ISO, the International Organization of Standardization, is a non-governmental independent international organization that develops standards for voluntary adoption among organisations worldwide. ISO's standards are developed through the collaboration of 163 expert national bodies so as to develop consensus-based and market relevant international standards with the aim of supporting innovative solutions to global challenges (About ISO, n.d.).

ISO has several management system standards of which the ISO 9001 series is just one. According to ISO, management systems are defined as follows:

> "A management system is the way in which an organization manages the interrelated parts of its business in order to achieve its objectives." (Management system standards, n.d.)

At present ISO has a large number of management system standards covering the following sectors:

- Quality
- Industry
- Safety and Security
- General management
- Health and Medical
- Environmental and Energy
- Information technology
- Services

ISO 9001 is a high level generic Quality Management System standard from the Quality sector of ISO's management system standards (Management system standards, n.d.). In contrast, the other standards in the series are industry and application specific. For example:

- ISO 10 006:2017 - Quality management -- Guidelines for quality management in projects
- ISO 13 485:2016 - Medical devices -- Quality management systems -- Requirements for regulatory purposes

ISO 9001:2015 is the latest revision of ISO 9001. Some of the major changes from the previous revision, ISO 9001:2008, include aligning the structure of the document to other ISO management system standards and an increased focus of risk based thinking (Moving from ISO 9001:2018 to ISO 9001:2015, n.d.). The alignment of the structure of ISO 9001:2015 to other ISO management system standards was done with the aim of easing integration between management systems.

Included in the structure of the ISO 9001:2015 are the following aspects (ISO 9001 Quality management systems, 2015):

- Clause 1: Scope
- Clause 2: Normative References
- Clause 3: Terms and definitions
- Clause 4: Context of the organisation
    - This section pertains to understanding the context of the organisation. This includes determining the needs and expectation of interested parties. In addition, requirements are set to determine the scope of the quality management system and the processes that govern it.
- Clause 5: Leadership
    - In this section, requirements pertaining to leadership and their commitments are set. This includes the requirement for leadership to promote a customer focus in the operations of a department.
- Clause 6: Planning
    - This section provides guidance on planning for actions to address risks and opportunities. This is in addition to providing guidance as to how changes in the environment in which an organisation operates should be handled.

- Clause 7: Support
  - This section is concerned with making sure that the organisation is equipped to run its operations and looks at resources and documented information.
- Clause 8: Operation
  - In this section operational planning and control is discussed. This includes customer need identification and communication channels and the design of products and services.
- Clause 9: Performance evaluation
  - This section pertains to monitoring and measuring performance of the activities of an organisation. This includes the control of products and serves, availability of records and control of non-conforming products.
- Clause 10: Improvement
  - This section provides guidance on continual improvement of products and services rendered by and organisation. This is in addition to taking corrective measuring for areas of non-conformance.

2.3. ISO 9001 implementation base and advantages

The ISO 9001 series is the most extensively implemented ISO management system with an implementation base of 1.1 million accreditations across the world (Figure 3).

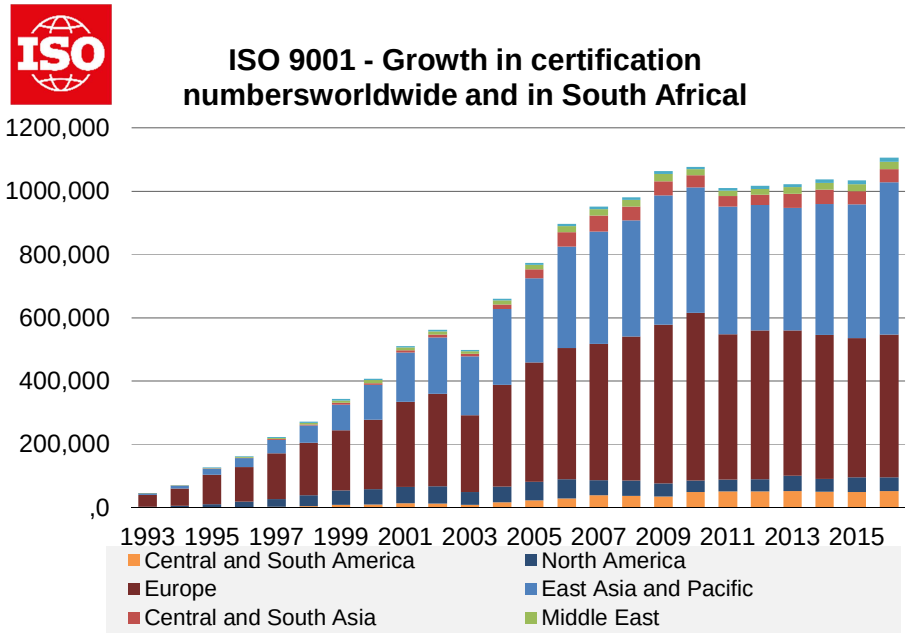

Figure 3: Number of ISO 9001 accreditations worldwide (The ISO Survey of Management System Standard Certifications, 2016).

The next largest implementation base being ISO 14 001, standing at a quarter of ISO 9001's implementation base (The ISO Survey of Management System Standard Certifications, 2016).

Two factors can be attributed to this wide implementation base:

1. Increasingly ISO 9001 is becoming a pre-requisite for doing business in both the private and public sector (McAdam & Canning, 2001).
2. In addition, ISO 9001 is generic in nature and therefore applicable to all industries (ISO 9001 Quality management systems, 2015).

The advantages of ISO 9001 accreditation are well established. Rusjan & Alič (2010) found the following benefits upon doing a review of empirical research done up to 2010:

- A reduction in potential negative effects as a result of non-conformances identified.
- A reduction in operational costs as a result of continuous improvement of operations.

- An increase in revenue due to improved quality of products and the assurance of better quality due to certification.
- Performance enhancement from improved efficiency leading to better profitability and return on investment.

2.4. Implementation considerations

Despite the benefits of ISO 9001 certification, there are still challenges in implementing ISO 9001 in a sustainable way. A study by Zeng et al. (2007) found that 63% out of 125 Chinese companies surveyed had cases a perfunctorily implemented ISO 9001 QMS. The most pertinent barrier, as reported by 42% of the companies surveyed, is a "Short-sighted goal for 'getting certified'". The motivation for seeking certification, therefore, remains external to the company. Note that, in line with this study, SOEs made up 37% of the sample size for this study. This was the largest group amongst the ownership type category.

Findings by Zeng et al. (2007) link to a case study by Sampaio, Saraiva & Monteiro (2012). In this study, it was found that the ease with which benefit derived from certification could be quantified is related to whether the motivation for seeking certification was internal or external to the organisation. For organisations where the motivation for certification was internal, that is to say, that they were seeking certification in an effort to improve their own outputs, quality managers were unable to quantify the benefit gained. If the source of motivation was external, for example, if the organisation requires certification in order to qualify for tenders, then the benefit was easy to quantify since their customer base and turnover increased specifically due to obtaining accreditation.

For organisations that foster external motivations for seeking certification, it is easy to fall into the trap of "ceremonial conformity". Biazzo (2005) investigated this phenomenon in the Veneto region of Italy. He found evidence of "ceremonial conformity" in the audit phase of an implementation where auditors merely assess whether a company's documented processes comply with requirements on a superficial level, rather than checking whether they are effectively capturing organisational best practice. Apart from the organisation obtaining a certified status, this approach does not in actual fact ensure continual improvement and quality assurance as is the aim of the standard.

Yeung et al. (2003) showed through an empirical study that “attitudes to implementation” and “confidence of understanding”, both among senior executives, are the most influential factors for a successful implementation of ISO 9001. Therefore, it is critical to take leadership’s “understanding” and “attitude” into account during the development of an ISO 9001 implementation initiative.

As part of this review, studies on implementation methods for ISO 9001 could not be found in literature. This is possibly because the implementation methods are mostly generic and therefore not distinguished and defined in literature. Rather, the benefits of certification (Rusjan & Alič, 2010) and barriers to implementation (Zeng et al., 2007) of ISO 9001 implementation are studied. Research by Yeung et al. (2003) provides contributing factors to successful implementations; however, no further guidance is given as to practically how their recommendations should be implemented. Since there is a lack of research on implementation methods, answering the research question set in this study will be a valuable contribution to the body of knowledge on ISO 9001 implementations.

Another reason for the lack of literature on implementation methods could be that ISO management system standards are often implemented in organisations by consultants. The implementation methods and frameworks used by consultants would be propriety to a consultancy company and therefore would not be in public domain or academic literature.

Despite the lack of literature specifically on the methods and tools used for the implementation of ISO 9001, it is known that a common method used is the checklist implementation method applied at a departmental level. In the checklist, an interpretation of the standard’s requirements is listed. Departments are assessed to determine their level of compliance and gaps are addressed through an action plan. It can be asserted that the checklist presents requirements in a way that is foreign and disconnected from the existing operations which then can lead to a superficial implementation of the ISO 9001 requirements.

There are countless factors influencing a company’s performance. It can be difficult to isolate how any one improvement initiative impacts performance. This is consistent with findings by Sampaio et al. (2012) on organisations that have in internal motivation for getting certified. This is not to say that accreditation does not hold benefits for an organisation, but merely that benefit from accreditation is difficult to quantify. As

mentioned earlier, a multitude of studies as analysed by Rusjan & Alič (2010) have confirmed well-established evidence of benefits of ISO 9001 accreditation.

Furthermore, Lee & Palmer (1999) found that implementing and maintaining an ISO 9001 certification demands considerable effort and there are many challenges involved. The study found that for large companies, the most pertinent challenges are:

- Monitoring employee's everyday adherence to the standard's requirements
- The quantity of paperwork
- The organisations documented processes do not reflect employee's actual activities

The last point of this is also consistent with finding by Biazzo on "ceremonial conformity" discussed earlier. Since implementing and maintaining an ISO 9001 accreditation takes considerable effort it follows that organisations would naturally want to maximise on the benefits gained from this effort.

Allur et al. (2014) found that this could be achieved through the proper internalisation of the standard's requirements. They found that a higher level of internalisation of ISO 9001 requirements yields greater benefits for organisations. Furthermore, they assert that companies should implement ISO 9001 with the aim of improving everyday operations. This is as opposed to doing the minimum mainly for compliance reasons. This approach still requires substantial effort but yields low value for organisations.

This does raise the question as to how this internalisation can practically be achieved. It is clear that considerable further benefit can be derived if organisations turn their motivation inward and seek to implement ISO 9001 in a way that creates real quality improvement and assurance. However, from the narrative literature review done for this study it is unclear how improved internalisation can be done practically. Work by Ainsworth and Loizou (2003) and Ollerenshaw et al. (1997) potentially provides a clue.

Ainsworth and Loizou (2003) found that in preparation for a biology test, learning is more effective when information is presented in diagrams. This is supported by research done by Ollerenshaw et al (1997). They performed an experiment where undergraduate students were subjected to information in four different presentation forms, namely:

- Text only

- Text in conjunction with diagrams with labels
- Text in conjunction with diagrams that illustrate major operating stages
- Full multimedia diagrams

They found that, in general, subjects performed better when subjected to material in a multimedia diagram format. Though the environments are very different, one may speculate that organisational learning and therefore ability to implement ISO 9001 requirements might also be more effective if the information is presented in an interactive computer-based diagram. This can potentially contribute towards enhanced internalisation of the standard's requirements into existing operations.

In view of this, considerable further benefit can be derived if organisations turn their motivation inward and seek to implement ISO 9001 in a way that creates real value in terms of quality improvement and assurance. This is as opposed to fostering an external motivation for seeking certification that, at times, results in "ceremonial conformity" as found by Biazzo (2005). A diagrammatic or flowchart type implementation framework can possibly assist in achieving this goal by promoting better integration of requirements into existing operations.

2.5. ISO 9001 in the South African context

Over the years accreditations worldwide have steadily increased as can be seen in the bar graph in Figure 4. The number of accreditations in South Africa has followed the same trend of steady growth as can be seen in the line graph in Figure 4 to the 4761 accreditation in South Africa when last measured in 2016 (The ISO Survey of Management System Standard Certifications, 2016).

When compared to other BRICS countries (Brazil, Russian Federation, India and China) South Africa is at the lowest end in terms of number of accreditations (Table 2). However, on further investigation, it was found that more or less one out of four firms in South Africa is ISO 9001 accredited. The adoption rate in South Africa ranks mid to high when compared to other BRICS countries. China ranks first amongst BRICS countries with an adoption rate of 53.4% whilst India and South Africa follow with 27.5% and 26.4% respectively. Notwithstanding this mid to high adoption rate, there is limited published

research in existence concerning ISO 9001 in both the South African public and the private sector.

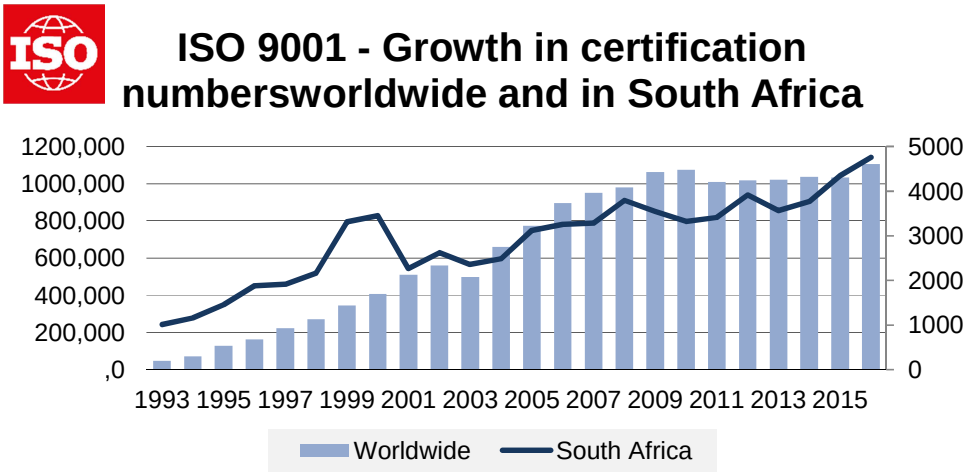

Figure 4: Number of ISO 9001 accreditations in South Africa (The ISO Survey of Management System Standard Certifications, 2016).

Table 2: BRICS ISO9001 adoption percentages

Country	Total number of ISO 9001 accreditations in 2016[1]	The degree of ISO 9001 adoption[2]
China	350 631	53.4%
India	37 052	27.5%
South Africa	4 761	26.4%
Brazil	20 908	13.1%
Russian Federation	5 083	12.6%

[1] The ISO Survey of Certifications (2017)

[2] Wolfram|Alpha (2018)

Apart from studies by Smith (2013) and Turner, Ortmann & Lyne (2000), there is not much published research on ISO 9001 implementation within the South African context, let alone SOEs.

Smith (2013) investigated quality management performance at Eskom's Nuclear Power Station with a specific focus on the audit monitoring program. Internal auditing is part of the requirements of ISO 9001. The study involved looking at the effective use of the data generated by the audit monitoring program. It found that the data was being underutilised. In addition, the study found that by including theming and additional severity metrics during

analysis of audit results, this can be utilised by leadership in providing high- level strategic direction. Findings by Smith (2013) suggest that more value might be derived from ISO 9001 accreditations at SOEs. This is consistent with the aims of this study.

Turner et al. (2000) did a study on the uptake of the ISO 9000 series among South African Agricultural businesses. Note that ISO 9000 refers to the family of standards pertaining to QMS. It was found that firm size was the most significant variable distinguishing between businesses that acquired an ISO 9000 certification and businesses opting for an alternative quality related accreditation.

The study by Turner et al. represents the sum of peer-reviewed published research on ISO 9001 in the South African context. In light of this, there is still immense scope for more research to be conducted on ISO 9001 in both the South African public and the private sector. This is especially relevant considering the growth in accreditation numbers in South Africa.

2.6. Literature review summary

ISO 9001 is the most widely implemented management system standard from the ISO series with 1.1 million accreditations worldwide (The ISO Survey of Management System Standard Certifications, 2016). Certification numbers in South Africa have steadily increased over the years with one out of every four companies holding accreditations. Therefore any means of optimising the value obtained from ISO 9001 accreditations will make a big impact, simply because of the sheer numbers of accreditations worldwide and in SA.

Listed below are two ISO 9001 relevant aspects that are well researched:

- The benefits of accreditation (Rusjan & Alič, 2010).
- The barriers to implementation (Zeng et al., 2007).

However, there is a gap in the literature with regards to the method used for implementing the standard's requirements. This study endeavours to contribute to filling this gap by firstly putting forward a novel implementation method and, secondly, in evaluating it in comparison the current implementation methods available, namely the Checklist method.

As discussed in Section 2.4 there is a general lack of research concerning ISO 9001 in both the South African public and the private sector. This research stands to add a valuable contribution to the body of knowledge of ISO 9001 implementation within a South African context specifically with regards to manager's attitude towards the implementation of the standard.

Chapter 3

ISO 9001:2015 Implementation framework development

In the literature review, key concepts were identified to be used in the development of the implementation framework. These concepts were used in setting the aims and identifying the target audience of the implementation framework. Prior to the inception of the development process, the scope and novelty aspects of the framework was clearly defined. Subsequently, the framework was developed to cover three high-level aspects, the process approach, a focus on customers and activity related requirements. In this Chapter, motivation is given for all the development choices that were made as part of the implementation framework development.

3.1. Implementation phases

For illustration purposes, the Plan-Do-Check-Act cycle (PDCA), as develop by Deming (2018), was adapted to model a generalised process flow for the implementation of ISO 9001 (Figure 5). This illustration is provided so as to clarify where, in this process flow, this improvement initiative is focused. As mentioned before, not much literature is available on overcoming barriers to sustainable implementation. This is apart from recommendations by Zeng et al. (2007) pertaining to the “Check/Audit” phase.

It can be argued that there is merit in focusing improvement efforts on the “Plan/Development” and “Do/Implementation” phases. Since these two phases are early in the process flow, it constitutes a pro-active approach to bringing about improvement in the adoption of management systems.

Therefore, for the purposes of this study, the focus will be on the “Plan/Development” and “Do/Implementation” phases of the process flow illustrated in Figure 5.

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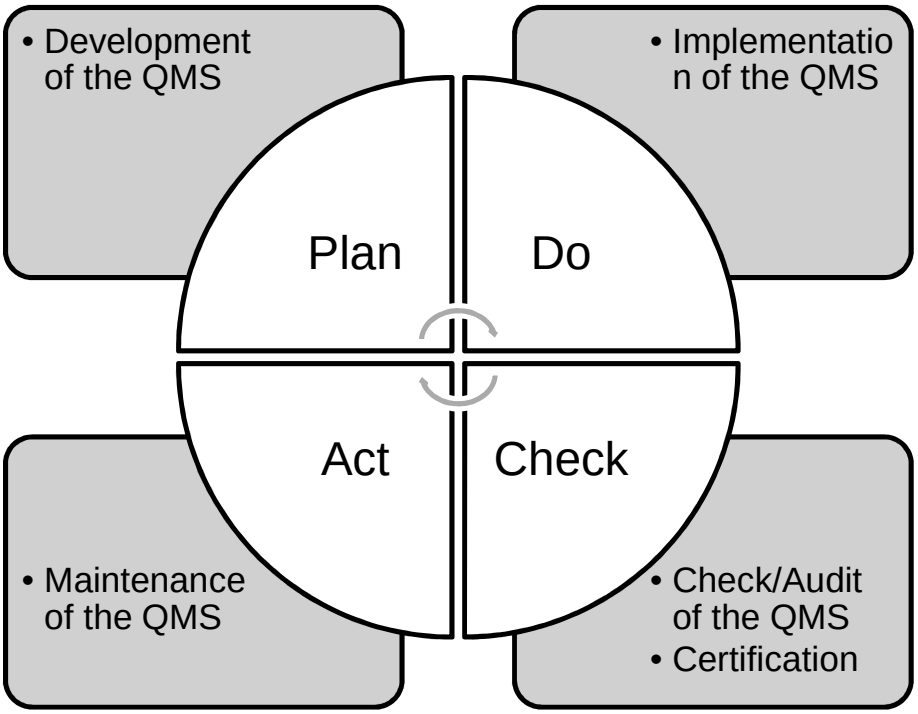


Figure 5: Adaption of the Plan-Do-Check-Act for the management system adoption process flow (Adapted from Deming, 2018)

3.2. Aims and requirements

This Section pertains to Objective 1, developing a novel implementation framework for ISO 9001:2015 by utilizing knowledge transfer best practice so as to promote internalisation of the standard's requirements (Objective 1).

In fulfilment of Objective 1, a novel implementation framework is proposed where the requirements for ISO 9001:2015 are presented in an interactive flowchart format that is editable to allow leadership to populate it with information from their own environments.

For the development of this framework a set of requirements were established as listed in Table 3. In addition, supporting arguments for each requirement is also provided in Table 3. These requirements served as the foundation for the development of the framework.

Table 3: List of requirements for the development of the novel implementation framework.

Requirement/Aim	Supporting arguments
Alternative to current implementation method	Typically, ISO 9001 implementations are done by means the Checklist implementation method. It may be asserted that the checklist implementation method is not the best way to communicate and internalise ISO 9001:2015 requirements. Reasons for this assertion is given below: • Knowledge transfer by means of Checklist implementation method is consistent with presenting information in a paragraph format. This is because it presents requirements in a way that is foreign and disconnected from the existing operations. • The Checklist method is more geared towards audits. So, by using a checklist for an ISO 9001 implementation, in actual fact constitutes using an aid appropriate for the "Check/Audit" phase for the "Do/Implementation" execution phase (Figure 5). Potentially, these aspects associated with the Checklist implementation method contributes to the issue of superficial ISO 9001 implementations found in literature (Zeng et al., 2007) in addition to evidence of ceremonial compliance (Biazzo, 2005).
Build an interactive diagram	In addition to findings by Ainsworth et al. (2003), Ollerenshaw et al. (1997) found that if diagrams are in multimedia format learning is further enhanced. By using the concepts as proposed by Ainsworth and Loizou (2003) and Ollerenshaw et al. (1997), the framework developed for this study intends to communicate ISO 9001:2015 requirements more effectively by presenting ISO 9001 requirements in an interactive computer-based diagrammatic format
Promote internalisation	Research by Allur et al. (2014) found substantial evidence that greater benefits are derived from an ISO 9001 accreditation if there is a higher level of internalisation of the standards requirements. In contrast to the checklist implementation method that creates a situation where the QMS is external to the operations of an organisation, the proposed implementation framework will promote internalisation by placing the operations of an organisation at the centre of the QMS. Subsequently, the aim is to lead managers through the requirements of ISO 9001:2015 on exactly how these requirements relate to their environment during the "Do/Implementation" phase of an ISO 9001:2015 adoption process (see Figure 5). The concepts as discussed above were used in the development of the proposed implementation framework.

3.3. Target audience

Yeung et al. (2003) found that the most significant factor for the development of a QMS is senior management's confidence in the understanding of the ISO 9001 standard. For this reason, it is important to take leadership's perspective into account in the development of this framework. However, note that this finding pertains to the "Plan/Development" phase of a QMS and not the "Do/Implementation" phase as such. In addition, it was found that despite senior management's understanding of requirements being a critical factor for the development of a QMS, it does not necessarily lead to improved performance of the organisation. It can be argued that even though senior management's understanding of ISO 9001 will assist with the "Plan/Development" phase of a QMS, it will have little effect on performance if the QMS is not effectively integrated into the operations of the organisation. This is consistent with research by Allur et al., (2014) as discussed earlier, which found that higher levels of internalisation lead to greater benefits derived from an ISO 9001 accreditation.

Therefore, with the aim of the framework set on improving internalisation of ISO 9001 requirements, the target audience chosen for this implementation tool is first line management. First line managers interact with staff on a daily basis and are intimately involved with the operations of various departments. Employee buy-in and involvement are paramount during "Do/Implementation" and for the "Maintenance" of a QMS (Cheng and Rao Tummala, 1998). In addition, Anholon, Rampasso, Ordonez, Silva, Qualas and Filho (2018) investigated difficulties in the implementation of ISO 9001 and found the following staff-related difficulties::

- Resistance to adoption among employees
- Lack of comprehension of how ISO 9001 can improve the operations of an organisation
- Training on quality principles not rolled out to all employees

With regards to these difficulties, first line managers are the main influencers at this level of staff and are therefore a natural choice as a target audience.

3.4. Scope

Generic requirements of management systems are often implemented independently in each department of an organisation. In this context, generic requirements refer to the requirements of the standard that are universally applicable across the entire organisation. This is in contrast to requirements that are only applicable to support service departments such as human resources, finance and procurement.

This approach is necessary to ensure compliance across big enterprises, but it means that the implementation of the new system runs concurrently in each department. Consequently, the total man-hours spent quickly accumulates due to the multiplication effect. In view of this, it follows that organisations would want to maximise on the value realised from the time spent on implementation in each department.

For the scope of the framework it was decided to include only the generic requirements of the standard. It is argued that in doing so, it ensures that the framework is generic and therefore applicable to all industries. In addition, it avoids overcomplicating the framework with requirements only applicable to a small section of departments in an organisation.

3.5. Novelty

ISO 9001:2015 is a process orientated standard. It follows that processes, usually illustrated by means of diagrams, are part and partial of ISO 9001. However, ironically ISO 9001 is widely implemented by making use of a checklist.

This framework seeks to provide an alternative to the traditional checklist implementation method. As mentioned, the scope of this framework is limited to include only the generic requirements of the standard. It is novel in that generic requirements of ISO 9001:2015 have not before been illustrated in a consolidated way as is done in this framework. It is also novel in the sense that the process flow itself is presented to the users in an interactive and editable format to a very high level of detail.

A narrative literature study strategy was followed for this study. No other models in literature could be found to have the combination of these two attributes. Therefore it may be asserted that the model developed is novel in terms of providing a new method for the implementation of ISO 9001:2015 requirements.

3.6. Framework development

3.6.1. The process approach

The process approach, as depicted in Figure 6, is a ISO 9001:2015 methodology for modelling a company's operations in a simple an effective way (ISO 9001 Quality management systems, 2015). In addition to its inclusion in the ISO 9001:2015 standard, this model is also adopted among several other ISO management system standards such as:

- ISO 14001 – Environmental management system standards
- OHSAS 18001 – Health and Safety management system standard, and
- ISO 27001 – Information security management system standard
- ISO 55:001 – Asset management system standard

It is universal in nature and can be applied to any organisation regardless of size or complexity. In essence, it sets out the organisation's activities in an organised manner.

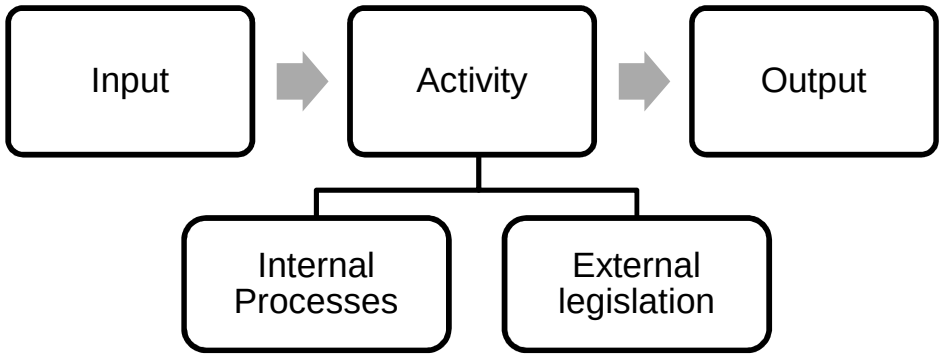


Figure 6: The process approach (ISO 9001 Quality management systems, 2015)

Since the process approach is central to the ISO 9001:2015 standard and it is already in flowchart form, it is clearly a good place to start for the development of an implementation framework. As discussed in Section 2.2, Clause 4 of the standard sets requirements for the context of the organisations (ISO 9001 Quality management systems, 2015). By documenting the operations of the an organisation by means of the process approach the context of the organisation is documented and understood as required in Clause 4 of the standard.

Figure 7 provides a detailed view of how the process approach can be applied to a department's operations. It is helpful to first consider the inputs and outputs of a department. Inputs are regarded as the info, energy or matter that triggers or mandates work within a department. Customer and or organisational needs and specifications should supplement these triggers, where customer needs are especially pertinent in design environments.

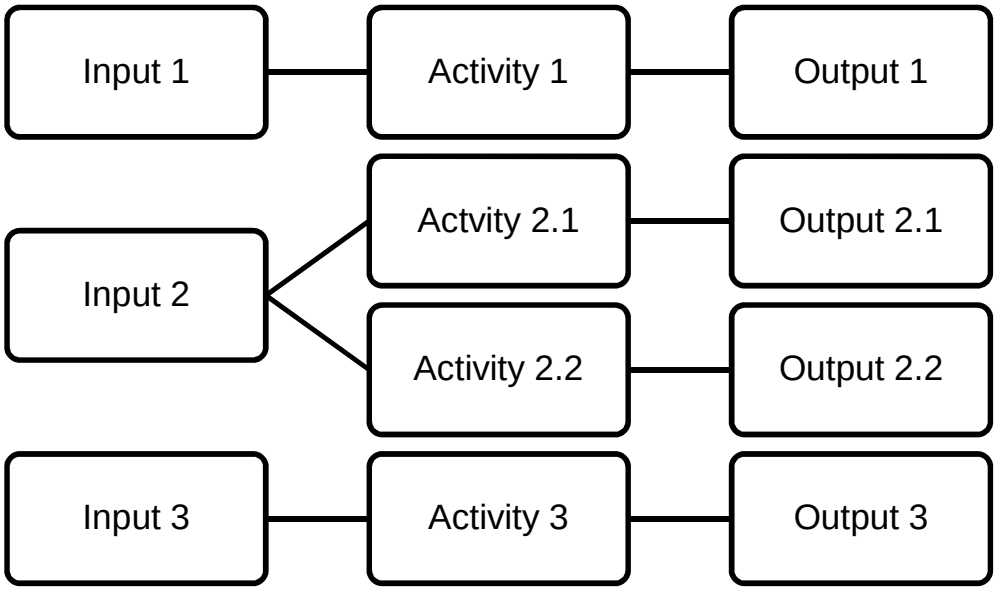


Figure 7: Detailed view of the application of the process approach

Outputs are the products or services that a department either renders to an end customer or to another internal department. Inputs are then linked to outputs via activities. An activity is the route that the input (in the form of info, energy or matter) takes to get to the output. As illustrated in Figure 6, the standard requires that one or more internal governing document and/or external legislation guides the activity.

The process approach was taken as the starting and central point for the development of the implementation framework.

3.6.2. Customer focus

Clause 5 of the 2015 revision of the ISO 9001, as discussed in Section 2.2, puts increased emphasis on the need for organisations to foster a customer focus. In addition, Clause 8 that is concerned with operations, sets requirements for determining customer needs in terms of product and service provision and Clause 10 is concerned with continual

improvement in meeting customers' needs and expectations (ISO 9001 Quality management systems, 2015). Consequently, it was decided to identify customers and their needs early within the flow of the framework. For large organisations, where the end customer is far downstream from the output interface of a department, it can be difficult to adopt a customer focus. Because of the lack of end customer proximity, it is easy to lose track of customer needs and to turn the department's focus inward. This is evidenced by the well-known "silo" effect many organisations have difficulties with.

In addition, for large organisations, products or services are realised through a complex interaction between departments. In this way, departments are internal customers of one another. Due to the complexity of this interaction, it can be difficult to identify internal customers. It would be immensely helpful if managers could be equipped with a systematic methodology for identifying customers and their needs. This framework provides such a methodology.

Figure 8 provides the methodology developed in order to identify customers and their needs. The first step is to determine the fundamental function of the department. This assists in helping the manager to focus their efforts on their core business.

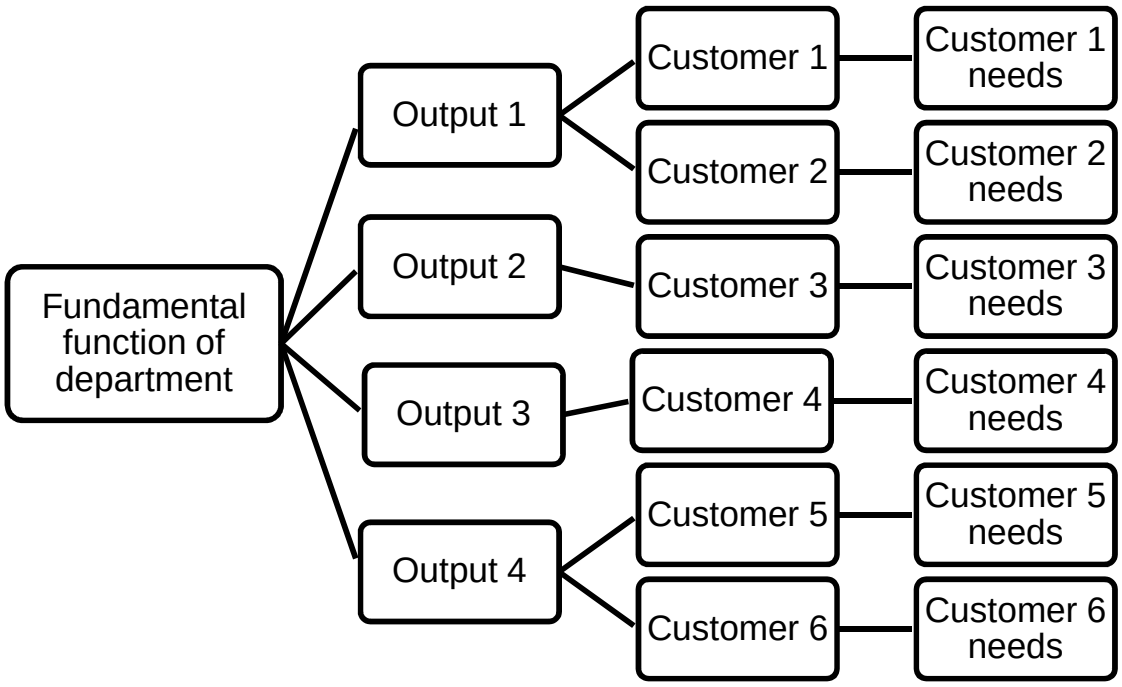


Figure 8: Customer need identification methodology

The fundamental function is then broken up into high-level outputs as illustrated in

Figure 8. From this point onwards, it is a simple task to identify the receivers or customers of these outputs. This will probably consist of a combination of internal and external customers depending on how close that department is to the external client interface. One output might also have more than one customer associated with it.

Once the customer list has been established the needs of customers are determined by reflecting on what that customers require in terms of the output that the customer has been associated with. All of this information is captured on the Quality Framework template. Through this process, customers and their needs are accurately and systematically identified and documented to be taken into account in the running of that department.

Interested parties are those entities that have an interest in the operations of a department. The definition of interested parties includes both direct and indirect customer in addition to regulating bodies. Direct customers and their needs have already been taken into account in the Quality Framework in the methodology provided in Figure 8. Therefore, direct customers can be excluded from the interested party list and needs since it is already covered in the methodology illustrated in Figure 8.

As discussed in Section 2.2, Clause 4 of the standard sets requirements for context of the organisation. This includes understanding the needs and expectations of interested parties (ISO 9001 Quality management systems, 2015). The same methodology to identify customers and their needs as illustrated in

Figure 8 is followed for identifying interested parties and their needs as illustrated in Figure 9. However, instead of identifying the needs of the direct receivers of the outputs, the compiler reflects on what are the needs of non-direct customers and regulating bodies.

It is important to take customers and interested party needs into account in a QMS for the following reasons:

- It ensures that the direct interfaces between departments operate as planned.
- It acknowledges the entire lifetime of the product or service provided by a department in the complex interaction of an organisation’s operations.

- It creates assurance that the entire workflow operates as planned, and not only the direct interfaces between departments.

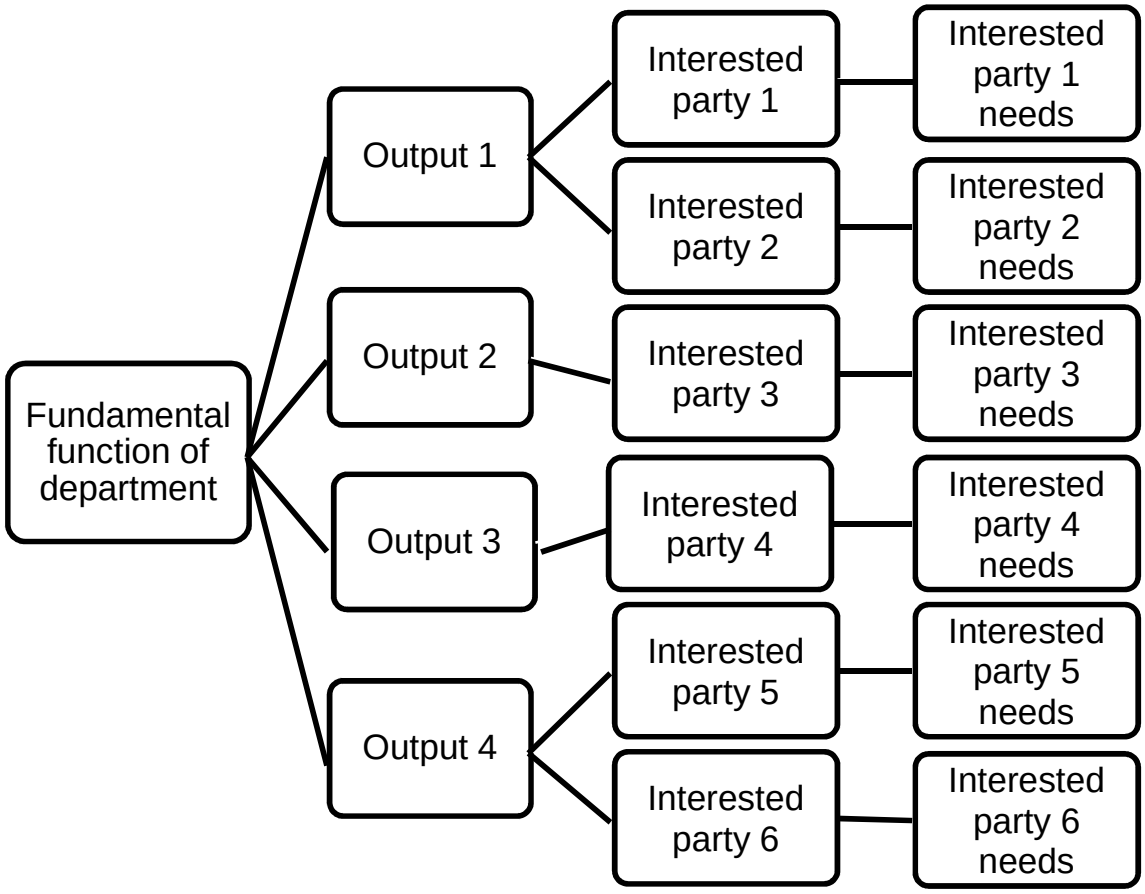


Figure 9: Interested party need identification methodology

If it is practical or if the company processes require it, the customer and interested party needs that were identified should be confirmed as accurate by those entities (ISO 9001 Quality management systems, 2015).

For the purpose of the framework, the customers and interested parties together are seen as a department's stakeholders. As part of maintaining a customer focus, the standard requires that stakeholders need to be engaged to determine their level of satisfaction with the product or service provided (ISO 9001 Quality management systems, 2015). The framework allows for the interaction between a department and its stakeholders to be effectively and accurately documented. Since the stakeholder needs have been identified in a focused way, stakeholders can be engaged on their specific needs and any

subsequent issues identified can also be addressed in a focused way. This is as opposed to the more commonly used generalised customer satisfaction form. Since issues can be accurately pinpointed, resources can be optimally utilised to address and correct these issues.

Figure 10 illustrates how the customer and interested party elements were consolidated with the process approach.

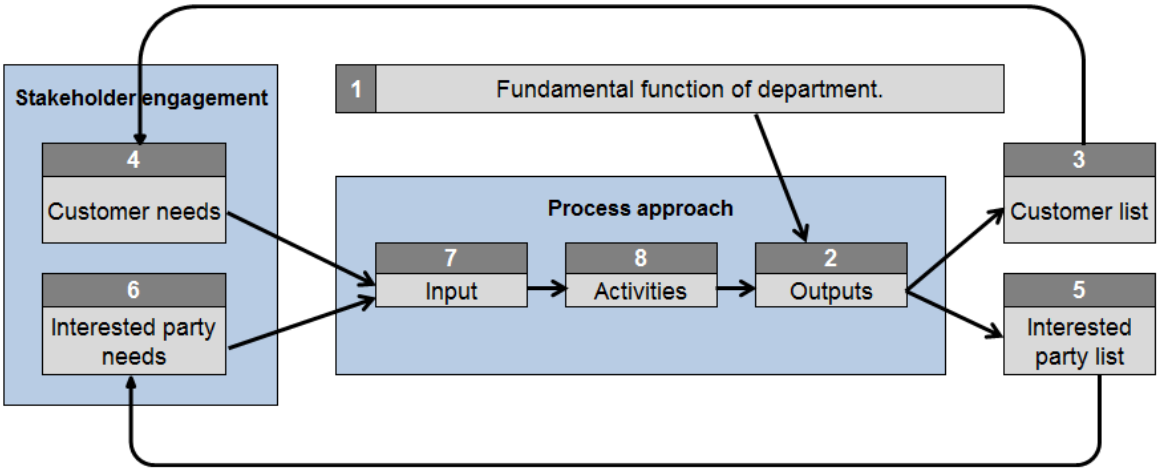


Figure 10: Preliminary framework consolidating the process approach with customer and interested party needs

3.6.3. Requirements relating to activities

As part of the process approach, a list of activities is identified for the department. Many of the standard's requirements are operational and therefore apply to the activities of a department. The activity related requirements identified from the standard are illustrated in Figure 11.

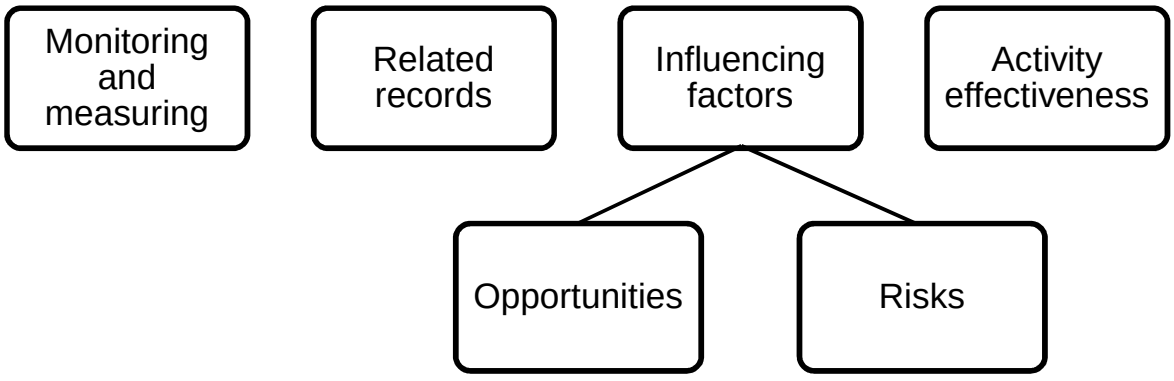


Figure 11: Activity related requirements

The first of these relates to monitoring and measurement systems, as illustrated in Figure 12. As discussed in Section 2.2, Clause 9 of the standard sets requirements for performance evaluation which includes having an organisational monitoring and measurement program. so as to ensure the conformity of products or services to a set of requirements (ISO 9001 Quality management systems, 2015).

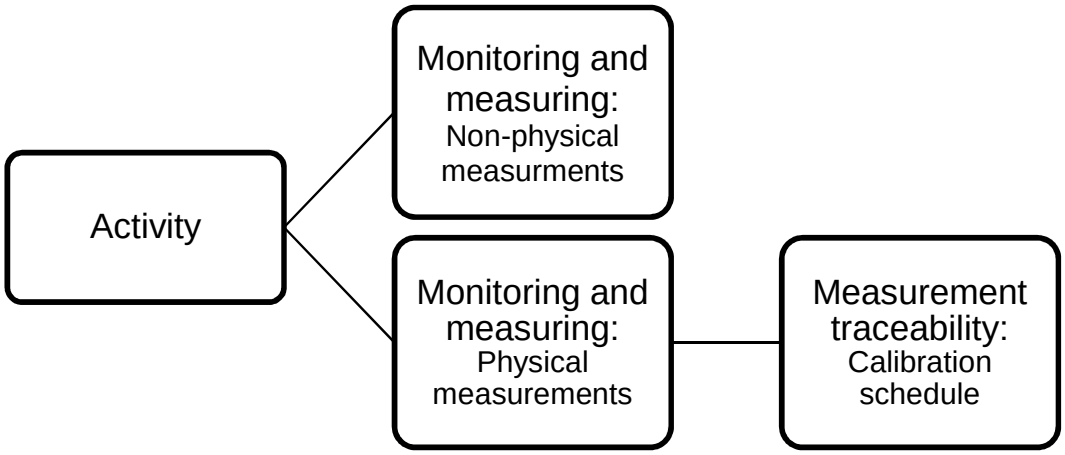


Figure 12: Monitoring and measurement process flow

This ranges from non-physical measurements, such as key performance indicators to physical measurement such as full gauge Repeatability and Reproducibility (R&R) studies.

The reason for including this in the scope of the QMS yet again relates to customer satisfaction. Customers have certain requirements for the products or services that they already have or plan to procure. These requirements are usually translated into a set of specifications. An organisation cannot be sure whether it is truly meeting those customer specifications if measurements are not being taken as part of its processes.

Monitoring and measurement programs provide a level of confidence that customer needs are being met. In addition, it follows that where physical measurements are being taken, the measurement equipment used should be calibrated to ensure measurements are true within an acceptable tolerance. For quality assurance, it is therefore essential that where measurement traceability is required, equipment is calibrated according to national or international calibration standards.

As discussed in Section 2.2, Clause 7 of the standard sets requirements for documented information necessary for the everyday running of an organisation (ISO 9001 Quality management systems, 2015). The standard requires that organisations keep records of the execution of its processes, which are the activities of that organisation. Recall that as part of the process approach, internal governing processes and external legislation that guide activities are identified. The motivation for keeping records of activities is to have confidence that the processes of the company are being adhered to and that legislation is being observed as planned. Figure 13 provides the detail of how the Quality Framework applies this concept to the activities identified as part of the process.

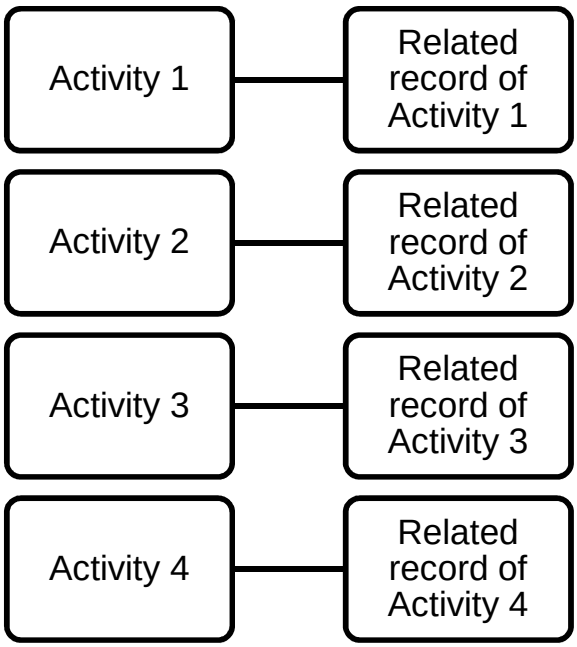


Figure 13: Related records process flow

Clause 6 of the standard sets requirements for planning in terms of determining those influencing factors, internal and external to the organisation, which affects its ability to deliver products and services as planned (ISO 9001 Quality management systems, 2015).. Through the framework as illustrated in Figure 14, the influencing factors are identified by reflecting on what factors affect a department's ability to carry out its activities, be it positive or negative factors. Subsequently, the positive influencing factors are translated into opportunities whereas the negative influencing factors are translated into risks. The standard then requires that action is taken to realise opportunities and to address risk.

As discussed in Section 2.2, Clause 10 of the standard sets requirements for continual improvement (ISO 9001 Quality management systems, 2015). If activities are not achieving their intended outcome, then these activities are ineffective. In these cases,

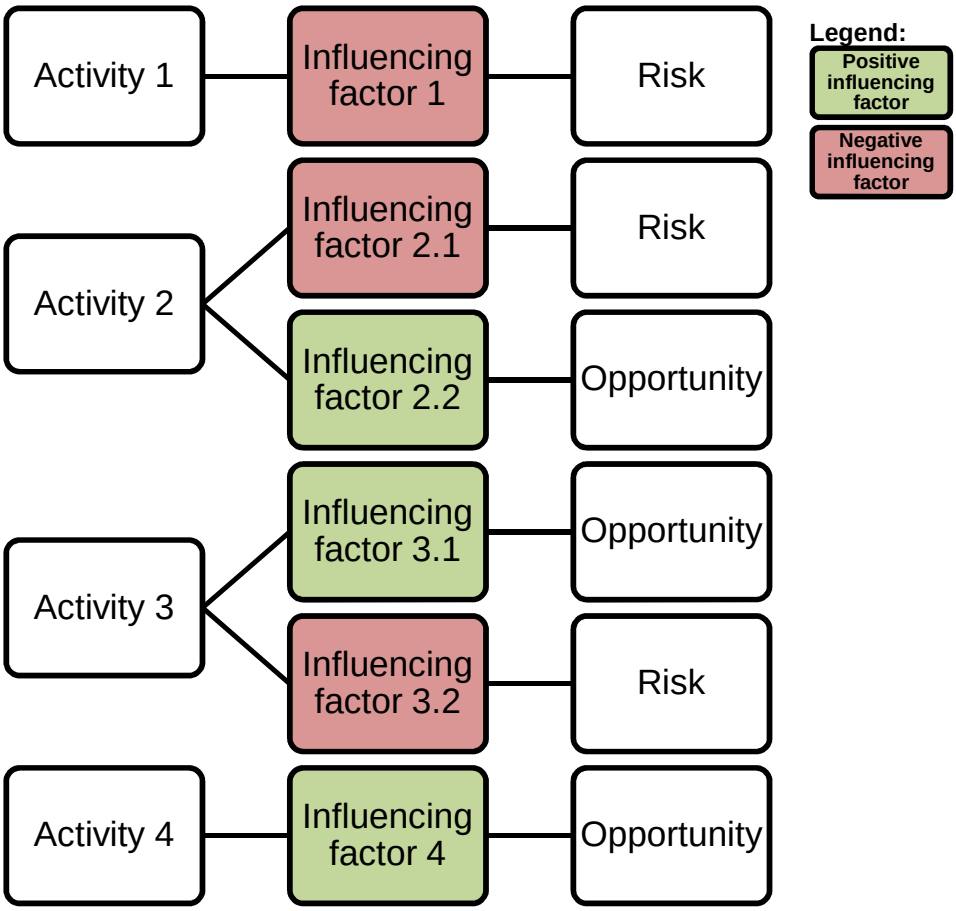


Figure 14: Influencing factors process flow

effort and resources may go into the activity, yet little or no value is being realised from it. To address this issue, the standard requires that the current practice with regards to the execution of an activity, be evaluated to determine whether these activities are effective. This is illustrated in Figure 15. The framework facilitates this process by leading the compiler to reflect on the current activity execution practice and identify areas that are ineffective in achieving planned outcomes. Once these issues have been identified, actions can be put in place to address these issues so as to ensure the improvement in the operation of an organisation.

Through the simple process flows that are individually illustrated in Figure 12, Figure 13, Figure 14 and Figure 15, the activity related requirements and their applications are effectively communicated to the user of the framework in a simple step by step manner.

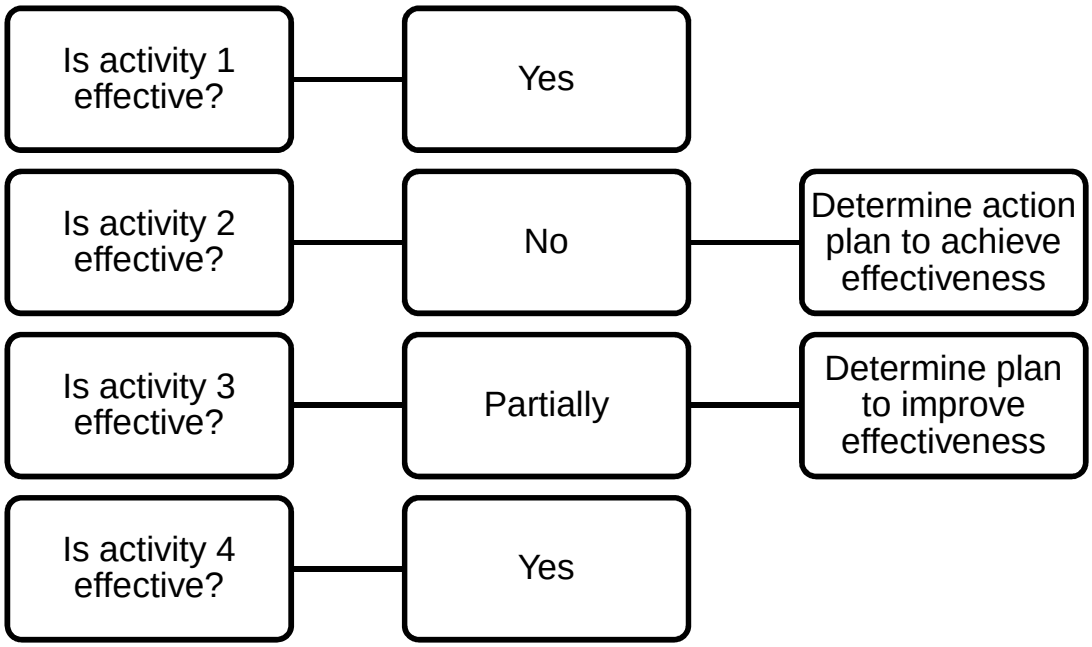


Figure 15: Activity effectiveness process flow

3.6.4. Consolidation of framework elements

Subsequently, the customer focus related requirement and activity related requirement elements as discussed in Section 3.6.2 and 3.6.3, were placed in an interactive flowchart format, centred around the process approach (see Figure 16). In doing so, the operations of an organisation are conceptually as well as physically placed at the centre of the framework, with signposts that gives detailed direction as to where and how ISO 9001 requirements apply to a department's operations. This is in addition to covering all the clauses of the standard in the various steps of the Quality Framework.

In the framework in Figure 16, numbers signify the order that the compiler will follow when populating the framework and arrows signify the relationship between these steps. The framework was developed in Microsoft Excel as it is easy to customise and most first line managers are familiar with the interface. For instance, when the user clicks on step 10, related records, the framework takes the user to the process flow as illustrated in Figure 13 (pg. 44). This is the case for each of the steps that make up the Quality Framework.

Through the framework, the relation between the ISO 9001:2015 requirements and the activities of a department are effectively presented and explained to the user.

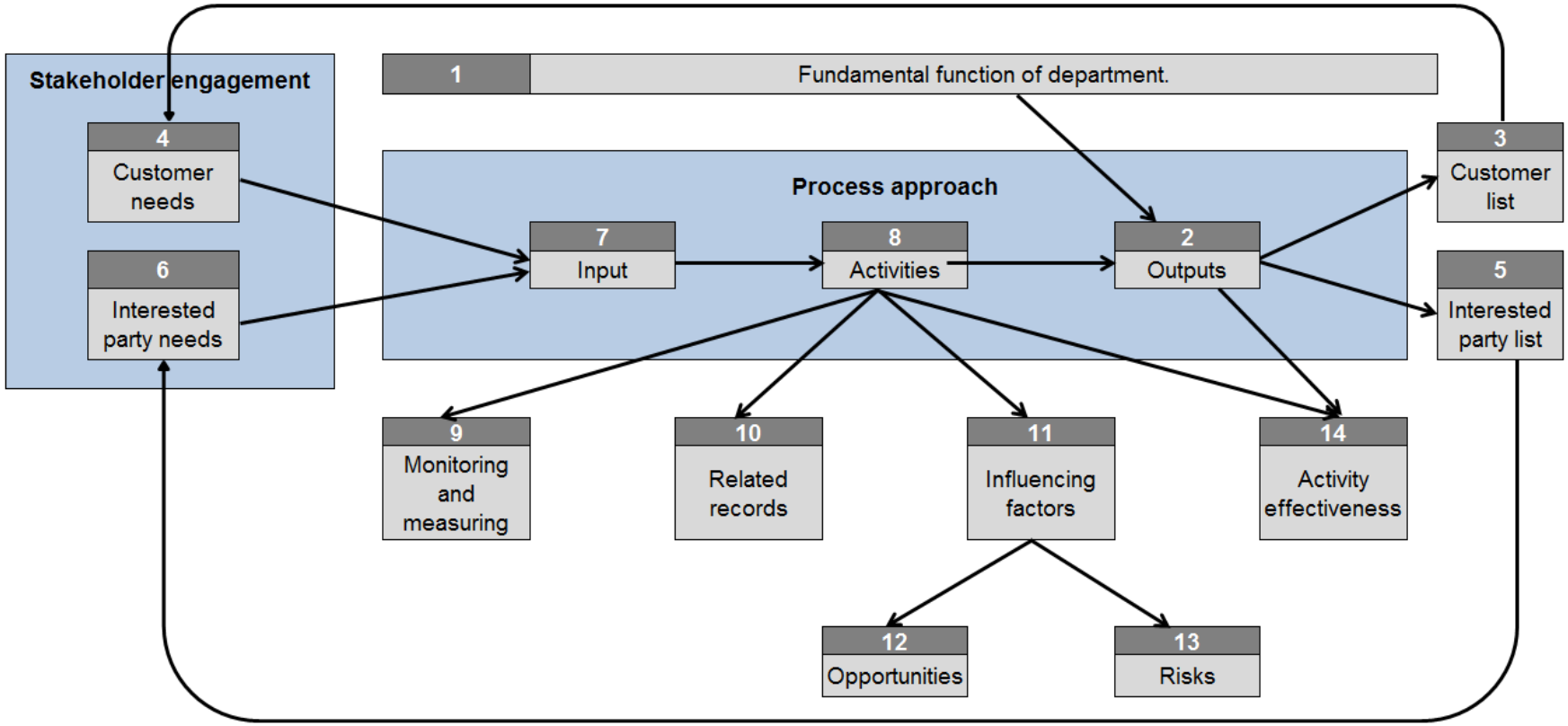


Figure 16: The consolidated Quality Framework

3.7. Piloting the framework

In order to test the framework the participating organisation made a sample of 25 departments available for a pilot of the Quality Framework. Since this process was significantly different from the checklist implementation method used the managers, the target audience of the framework, underwent a three-day workshop. In this workshop managers were trained on the Framework and how to apply it in their environments. In addition, they were guided through populating the framework so as to have a completed Quality Framework by the end of the training. The managers were then tasked to take the Quality Framework back to their own environments for implementation in their areas of responsibility,

This pilot represents a substantial endeavour with 25 first line managers taking part with a total compliment of around 1200 staff members.

3.8. Summary of implementation framework development

The implementation framework proposed as part of this project provides a systematic methodology for the adoption of the generic requirement of ISO 9001:2015.

This is as opposed to the common checklist method where implementers of the standards would as an example, merely be required to keep related records. The requirement in this format is loose standing and does not specifically link to the operations of a department. Because of this, it can be difficult to implement if one is not well acquainted with the standard. In contrast, the methodology provided by the framework leads the compiler on exactly how keeping records relates to the operations of a department and which records need to be kept.

By means of the structure created in the proposed implementation method, ISO 9001:2015 can be effectively and efficiently implemented.

Chapter 4

Survey development

In this Chapter, a comprehensive overview will be given of the development of the survey. The survey was designed to test managers attitude toward ISO 9001 depending on the implementation method used in fulfilment of the second objective set for this study.. This Chapter includes details around the method that was selected as well as the context and ethical considerations around the deployment of the surveys. Next, details pertaining to the survey development will be covered in terms of the Likert scale selected, the Likert item and time-related questions development.

4.1. Method selection

Since the framework being investigated is novel, there is no existing data that could be used to evaluate the impact or effectiveness of the Quality Framework. That is to say, there is no secondary data available for analysis. Therefore, in order to study the implementation of the Quality Framework, original data had to be produced. That is to say, primary data had to be generated to determine how the Quality Framework compares to the Checklist method.

As mentioned in the literature review, the impact of organisational quality initiatives is usually difficult to isolate and quantify empirically if the motivation for accreditation is internal (Sampaio et al., 2012). In addition, the impact of an ISO 9001 certification, that could possibly be empirically quantifiable, might only realise years after the implementation. As a compromise and alternative, managers' attitude towards ISO 9001 was identified as a metric to test the impact of the two implementation methods.

Consider findings by Yeung et al. (2003), discussed in Section 2.4, on the importance of leadership's "attitude" and "understanding" of ISO 9001 for a successful implementation of the standard. In view of these findings, it can be argued that measuring a manager's perspective can provide a reasonable perception of the impact of a particular implementation method.

Surveys offer the opportunity to collect quantitative data and subsequently analyse the data with descriptive and inferential statistics (Saunders, Lewis and Thornhill, 2009). Surveys that employ the use of a Likert scale allows for data to be collected pertaining to participants opinions or attitude. In view of this, the research method selected for this study is a Likert-style survey. It was decided to administer the survey electronically since it simplifies the process of data collection considerably for both the researcher and the participants.

The approach of using a Likert-style survey in research projects pertaining to the topic of QMS is not new as is evident from the two studies discussed below.

Magd & Curry (2003) performed a study where Egyptian companies were surveyed on their attitude towards ISO 9001. The questions in their survey were based on a five-point Likert scale. This included companies that were non-certified, certified and companies that were in the process of getting certified. The study finds that companies in Egypt have a good understanding of ISO 9001 and that the certification is most common among manufacturing companies.

Another similar study was conducted by Vouzas & Psychogios (2007). They investigated what they called the “soft” aspects of Total Quality Management (TQM). TQM is an alternative quality management approach and has its origins in the US Navy (Doherty & Howard, 1994). They report that the “hard” aspects of TQM are well researched as opposed to the “soft” aspects that still require further study. In this case, “hard” aspects refer to technical aspects such as QMS and tools whereas “soft” aspects refer to more generic quality management principles. From literature, they identified nine “soft” TQM statements. A total of 382 managers from the service industry where surveyed and were asked to rank their answers on a three-point Likert Scale. The analysis of the results yielded three statistically reliable components of TQM to characterise these “soft” aspects.

Though these studies are pursuing different objectives than those being pursued in this project, the similarity in terms of testing the perception of leadership on the topic of QMS is shared. For this reason, they provide a basis and credibility for the chosen method of this research project. It provides confidence that the second research objectives can be achieved in this manner.

4.2. Context of the survey

4.2.1. Setting of survey

The implementation framework was tested within a South African SOE. At the time of the initiation of this study, the organisation was certified under the previous revision of the standard, ISO 9001:2008, and was in the process of transitioning to the new revision of the standard, ISO 9001:2015. The transition to the new revision was initiated at the inception of 2018.

The framework was used as part of a pilot for the implementation of ISO 9001:2015 in a sample of operational departments within a SOE. The remainder of the departments was subjected to the existing checklist implementation method. The participating organisation is currently using the checklist method.

This SOE provided a good context for this research because of the diversity in outputs and the considerable size of the operations within this utility. Even though the organisation is not a clean slate in terms of ISO 9001, the transition process offered an opportunity to test the two implementation methods since the entire current management system is reviewed during the transition process.

The researcher opted to anonymise the organisation within all research documentation. This was done to protect the participating organisation in the unlikely event of the occurrence of negative effects as a result of the organisation's participation in this study. This was the only setting specific ethical issue identified. General ethical considerations associated with performing surveys are discussed in Section 4.4.

4.2.2. Survey participants

Recall from Section 3.3 that first line managers were selected as the target audience for the development of the Quality Framework. It follows that the survey should be deployed to managers on this level. As with the target audience, findings by Yeung et al. (2003) support the notion that managers perception will be a reasonable metric to measure the success of the framework by. This is in addition to first-line managers being the main influencers on the level were difficulties with implementation have been identified by Anholon et al. (2018).

With regards to the expected sample size for the survey participants, it was expected to obtain a minimum sample size of 15 for each implementation method to be surveyed. Though this expected sample size can be considered as quite low, it is limited by the number of respondents made available by the participating organisation that fall within the chosen target group of the study. Section 6.1 provides more detail around the actual response rate achieved.

4.3. Survey development

4.3.1. Survey scale selection and design

In a Likert-style survey, an attitude statement in conjunction with either an even or an odd number of options is provided to the participant. As part of the instructions, participants are asked to choose an option depending on how strongly they agree or disagree with the statement.

An odd number of points, such as a five-point or seven-point scale, is often used in Likert-style surveys and provides a mid or neutral option. However, a study by Matell & Jacoby (1971) finds that, in line with earlier studies, the reliability and validity of the scale is independent of the number of points on the Likert scale. Therefore, it is safe to say that depending on the study, a researcher can evaluate and individually decide what number of points to employ in a study.

For this study, a six-point scale was selected with options as illustrated in Table 4. The motivation for employing an even, as opposed to an odd, number of items on the scale is to have all the options on either the positive or negative side. For participants that are on the fence with regards to their attitude to a particular statement, having a neutral option provides an easy opt-out of choosing either a positive or negative viewpoint. However, chances are that these persons feel either mildly positive or mildly negative on the matter. By removing the neutral option whilst having the necessary grading in the scale to permit for mild views, allows for a sufficiently nuanced take on participant's viewpoints.

Table 4: Likert scale selected, 6 -point.

Strongly agree	Agree	Slightly agree	Slightly disagree	Disagree	Strongly disagree

4.3.2. Likert item development

Likert items are the attitude statements contained within a survey that employs a Likert scale. Surveys of this type consist of a collection of both positive and negative statements. The ratio between positive to negative statements should be more or less 50% (Ary *et al.*, 2018). In the survey, the items are roughly alternated between positive and negative statements. The reasoning behind this is to identify unwanted and unrepresentative responses where the participant merely chose the same response without considering the statement.

The list of Likert items that were produced for the purpose of this study is shown in Table 5. The inclination of the statement is provided in the second column, that is to say, whether the statement is positive or negative.

Table 5: Likert items for the online survey

Topic	Inclination	No	Likert item
Time and effort	Positive	5	Time spent on the “Quality Framework”/”Checklist” is worthwhile.
	Negative	6	Maintaining the “Quality Framework”/”Checklist” takes too much effort.
Attitude in general	Positive	7	At present, it is a priority to improve the operations of my department.
	Negative	8	The only reason I do the “Quality Framework”/”Checklist” is because my superiors require me to do so.
Value	Positive	9	The “Quality Framework”/”Checklist” provides useful methodologies to assist my department to perform better.
	Negative	10	The “Quality Framework”/”Checklist” does not add value to my department’s operations.
	Positive	11	The “Quality Framework”/”Checklist” helps my department to identify and address areas that need to improve.
Integration and effectiveness	Negative	12	ISO 9001 is mainly a documentation system.
	Positive	13	The “Quality Framework”/”Checklist” helped me to understand ISO 9001:2015 requirements
	Negative	14	I mainly spend time on improvement initiatives around the time of the Quality Management Review
	Positive	15	The “Quality Framework”/”Checklist” has positively changed how I think about my operations.
	Positive	16	The “Quality Framework”/”Checklist” helped me to see how ISO 9001:2015 relates to what my employees do every day.

These items were developed by choosing the topics to be covered in the survey and then developing opinion statements around these topics to cover the range of opinions potentially held on the topic.

Two surveys were conducted, one survey for the managers that was part of the Quality Framework pilot and the other survey for managers that used the existing checklist implementation method. For consistency, the same survey questions were used in each of the two surveys except for the referral to the implementation method differing depending on what method is used by the sample group. This is as indicated in Table 5 by means of quotation marks.

The survey was hosted on an online survey platform that allows for multiple choice answers by means of radio buttons.

4.3.3. Time-related questions in survey design

The time-related questions as set out in Table 6 and Table 7 were also included in the survey. These questions are not attitude related questions, and therefore not considered to be Likert items. These items were put at the start of the survey so as to create the context of when departments started with the transition journey and what amount of time managers spend on implementing and maintaining their QMS.

For the questions listed in Table 7, a five-point scale was applied. The motivation for this choice is that for these questions, five options on the scale provided sufficient grading between the options. It was argued that including a sixth option would have made the distribution between the points to small.

Table 6: Time related question on a six-point scale

No	Attitude object statements	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
1	When did you start with the transition to the new revision of ISO 9001:2015?	2 months ago	4 months ago	6 months ago	8 months ago	10 months ago	12 months or more

Table 7: Time related question on a five-point scale

No	Attitude object statements	Option 1	Option 2	Option 3	Option 4	Option 5
2	On average, what amount of time have you in person spent on implementing "ISO 9001:2015"/"the Quality Framework"?	No time, I have delegated this to my quality management representative.	8 hours or less	Between 1 and 3 working days	A full working week	More than a working week.
3	On average, what amount of time do you in person spend on maintaining your "ISO 9001:2015 system"/"the Quality Framework"?	No time, I have delegated this to my quality management representative.	A couple of hours a month	A couple of days a month	A week or two out of a month	More than two weeks out of the month
4	What portion of this time mentioned in the previous question is focused on improving my department's outputs?	0%	20%	50%	80%	100%

4.4. Survey deployment and ethical considerations

In order to prevent bias amongst the target group subjected to the Quality Framework pilot, the survey was deployed eight month after the initial training dates. This ensured that this group of managers had time to use the Quality Framework. Therefore, this group was not positively biased towards the Quality Framework, as would be the risk if the group was subjected to the survey soon after being trained.

The survey deployment involved contacting prospective participants via email. The email informed the participants that the online survey was part of a research study. Participants

were prompted on a weekly basis to remind them of the survey. The participants gained access to the survey landing web page by means of a hyperlink in the email. The participants only gained access to the survey from the survey landing webpage after they had confirmed that they had taken cognisance of the information in the informed consent form included in the email and that they consent to take part in the study.

Due to the structured nature of surveys, this method poses less of a risk for ethical issues since there is little opportunity to lead or influence participants (Dale, Arber & Procter, 1988). Nonetheless, ethical aspects were taken into consideration as part of the survey development and deployment process as listed in Table 8. In addition to these precautions being taken, the research study was also subjected to the University of Stellenbosch's ethical clearance process. The project was evaluated by the Research Ethics Committee and subsequently assigned with a "low risk" rating and approved.

This research study was subjected to the University of Stellenbosch's ethical clearance process. The project was evaluated by the Research Ethics Committee and subsequently assigned with a "low risk" rating and approved.

Table 8: Ethical aspects considered for this study

Ethical aspect	Considerations for this study
Data collection	Data for the purpose of this research study was generated by the researcher. This was done by means of an online survey. The data collected is in the form of responses to an online survey focused on the participants' attitude towards ISO 9001:2015 and time-related questions. No personal data was collected from the participants.
Initiating contact with prospective participants	Post the completion of the ethical clearance process, and permission being obtained from the participating organisation to contact participants, the researcher personally contacted prospective participants via email. The email contained a copy of the informed consent letter as well as the permission letter from the organisation.
Access to contact information	The researcher identified participants based on their designation within the organisation. No Stellenbosch University students or staff were invited to participate.
Fully informed consent	Prospective participants were fully informed via an informed consent letter that the survey is part of a research project. They were also informed as to what the research question is and how the data will be used. The University template for "Electronic Consent to Participate in Research" was used to ensure all ethical aspects are covered as part of the consent process. Participants only gained access to the survey once they provided consented as per the approved informed consent letter. The letter of permission for the research study as issued by the participating organisation was included to reassure participants that they have permission from the organisation to take part in the survey.
Coercion or unusual discomfort	The surveys were distributed electronically via email with a hyperlink to the online survey. In this manner, there was very little to no opportunity to coerce subjects or to create a situation where participants were subjected to discomfort.
Withdrawal	Since electronic surveys were used for data collection purposes, participants could easily withdraw from the survey at any time, even after they had consented to the survey.
Confidentiality and protection of participants.	Electronic surveys offer the option of keeping the participant's details confidential. Therefore, no personal data of subjects were collected or stored. Contact details and the results of the survey was stored on the primary researcher's personal computer that is password protected and kept in a locked office when unattended. Participants did not have access to other participants' survey responses. Only the primary researcher had access to the email address and the data provided by a prospective participant. The researcher undertook not to share any of the contact details of the participants with any other parties. Once this research project has been completed, the survey response results will be deleted from the primary researcher's personal computer.

4.5. Summary of survey development

With the aim of meeting Objective 2, a Likert style survey was selected as the method for testing the impact of the Quality Framework on managers' attitude towards ISO 9001. A pilot and survey were conducted within a South African SOE. The participants selected for the survey were first-line managers within the participating organisation. Two groups were surveyed, one survey was conducted among managers that formed part of the Quality Framework pilot and the other group was managers using the existing Checklist implementation method. Four time-related and twelve Likert items were developed to make up the questions of the survey. For the Likert items, a six-point scale was employed. Ethical considerations were taken into account in the deployment of the survey and were discussed in detail in this Chapter.

Chapter 5

Data analysis method

In this Chapter, details are given around the steps taken as part of the analysis of the survey data. Note that the focus of this Chapter is on how coding and tests were applied whereas the next Chapter, Chapter 6, is focused on the outcome of this process.

The method followed to analyse the survey data is illustrated in Figure 17. As illustrated in Figure 17, firstly the data was coded to a have a numerical value from either one to five or one to six. Since a six-point scale was used for the Likert items of the survey, it offered the opportunity to take another view of the data on a three-point scale. A detailed motivation for including re-coded data on a three-point scale in this analysis is given in Chapter 5.1. Next, statistical tests need to be applied to the data for both the six- and three-point scales. Chapter 5.2 gives details around the tests that were selected for this study and how they were applied. This is in addition to the Hypothesis setup for these tests at the end of this Chapter.

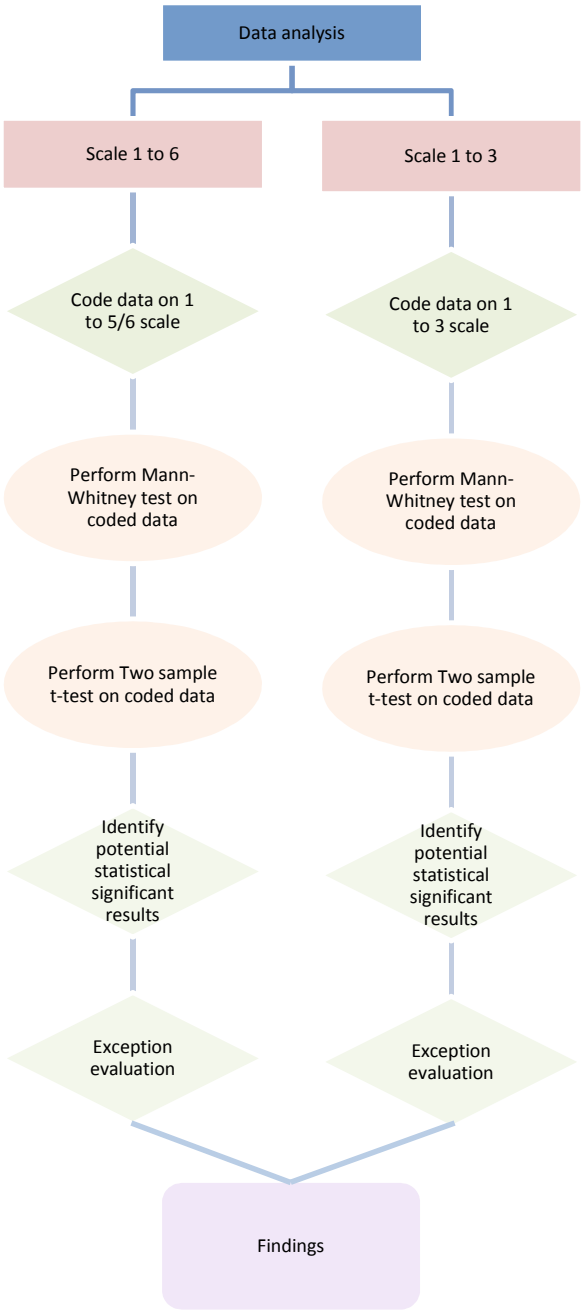


Figure 17: Method followed to analyse survey results

5.1. Coding of survey responses

To be able to apply statistical tests to survey data, the data needs to be coded to a numerical scale. A total of 16 questions were included in the survey, the first of which are time-related questions and the next twelve are Likert items.

Coding of the time-related questions are straightforward and was carried out as follows:

Question 1 has six options associated with it whereas Question 2 to 4 has five options. The motivation for this difference is provided in Chapter 4.3.2. Coding for Question 1 was done on a one to six scale as set out in Table 9. Questions 2 to 4 were coded on a one to five scale as per Table 10.

Table 9: Coding Schedule for Question 1

Range	Least time spent→					←Most time spent
Question 1	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Code	1	2	3	4	5	6

Table 10: Coding Schedule for Question 2 to 4

Range	Least time spent→				←Most time spent
Question 2 to 4	Option 1	Option 2	Option 3	Option 4	Option 5
Code	1	2	3	4	5

The rest of the survey questions, Question 5 to 16, were Likert items with a six-point Likert scale associated with it. These questions were coded as per the coding schedule in Table 11. Participant's responses were linked to a range from "Strongly negative" to "Strongly positive" and coded accordingly. Note that some of the questions were purposefully composed to have a negative inclination. The motivation for doing this is discussed in Section 4.3.2. Providing a "Strongly agree" response to a negative statement indicates a strongly negative attitude towards the topic. Similarly, providing a "Strongly disagree" response to a negative statement indicates a strongly positive attitude. Therefore, for negative statements, "Strongly agree", was taken as the lower extreme of the scale and "Strongly disagree" as the upper extreme as illustrated in Table 11.

Table 11: Coding of six-point scale survey responses.

Range	Strongly negative	Negative	Slightly negative	Slightly positive	Positive	Strongly positive
Positive Statements: Questions 5, 7, 9, 11, 13, 15 and 16	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
Negative statements: Question 6, 8, 10, 12 and 17	Strongly agree	Agree	Slightly agree	Slightly disagree	Disagree	Strongly disagree
Code	1	2	3	4	5	6

It can be argued that whether a response to a Likert item is "Strongly positive" or "Positive", that either response is representative of a person that has a positive outlook on the topic. The same goes for "Strongly negative" and "Negative" responses and holding a negative outlook. For "Slightly positive" or "Slightly negative" coded responses, the respondent potentially felt indifferent on the matter and could, therefore, be classified as "Indifferent". Since the scale used for the survey has an even number of points, it offered the opportunity to re-code the scale to a three-point scale. Therefore, as a further exploration of the data, the responses were re-coded as per Table 12 to a three-point scale to provide an additional coded response set for analysis.

Table 12: Recoding from six-point to three-point scale

Strongly negative	Negative	Slightly negative	Slightly positive	Positive	Strongly positive
1	2	3	4	5	6
1		2		3	
Negative		Indifferent		Positive	

5.2. Statistical tests and exception evaluation

Statistical significance tests are used to analyse coded survey data to be able to draw a comparison between samples. De Winter & Dodou (2010) did an investigation into whether parametric or nonparametric significance test procedures should be used to determine if there is a statistically significant difference in either the means or medians of the samples. In their study, a comparison was drawn between the prevalence of Type I

and Type II errors when either the Two-sample t-test or the Mann-Whitney test was applied to a range of different distributions of Likert survey data. The study found the two tests are generally equal in the power when used to analyse Likert questionnaire data.

However, there are exceptional combinations of data population distributions where the Two-sample t-test is more powerful in identifying Type II errors. The study provides a matrix to identify these cases. To mitigate the small risk of Type II errors due to exceptional combinations of data distributions, both the Two-sample t-test and Mann-Whitney test was applied to the coded survey data. Where the results between the Two-sample t-test and Mann-Whitney test are not in agreement, data sets need to be evaluated to determine if the data distribution combination falls under these exception pairs. If any of these exceptions are identified preference will be given to the results from the Two-sample t-test.

A detailed discussion of sample size and confidence intervals are given in Section 6.1 and 6.2, respectively. In short, sample sizes were 17 for the Quality Framework and 19 for the Checklist. A confidence interval of 90% was deemed as acceptable for this study since this research is not high risk.

Variable assignment and hypotheses setup are discussed next.

The Mann-Whitney test is a non-parametric statistical significance test that does a comparison between the medians of two sample sets in order to determine if there is a statistically significant difference between the medians of the two samples. Variables were assigned as set out below:

η_1: median of Question x when Type = Checklist
η_2: median of Question x when Type = Quality Framework
Difference: $\eta_1 - \eta_2$

The hypotheses for the Mann-Whitney test was set up as follows:

Null hypothesis H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis H_1: $\eta_1 - \eta_2 \neq 0$

The Two-sample t-test is a parametric statistical significance test that does a comparison between the means of two sample sets in order to determine if there is a statistically significant difference between the medians of the two samples. Variables were assigned as set out below:

μ_1: mean of Question x when Type = Checklist
μ_2: mean of Question x when Type = Quality Framework
Difference: $\eta_1 - \eta_2$

The hypotheses for the Two-sample t-test was set up as follows:

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

By performing both the Two-sample t-test and Mann-Whitney tests on the coded data in addition to performing exception evaluations, the probability of Type I and Type II errors are minimised. Rigorous research by De Winter & Dodou (2010) provided a concrete basis for structuring the data analysis method used in this study.

5.3. Summary of data analysis method

In summary, in order to analyse the survey data, the structured process set out in Figure 17 was followed. The survey responses were coded on both a six- and three-point scale so as to provide two response sets for analysis. The significance tests selected to be applied to the survey data is the Mann-Whitney test and the Two-sample t-test. These have been shown to be equal in power for most cases of data distributions. In exceptional cases, the Two-sample t-test is considered to be more powerful in identifying Type II errors. This aspect has been taken into account in this study by performing an exception evaluation. At the end of this Chapter, the variable assignment and hypotheses setup was done so as to set the scene for the results that are to follow in the next Chapter.

Chapter 6

Results

In this Chapter, the results from the survey process will be discussed. Firstly, the response rate obtained for the surveys conducted as part of this study will be discussed. Arguments around population and sample size will also be discussed as part of this. Next, the setup of statistical tests and the results obtained from these tests will be put forward. Following this, there will be an in-depth discussion of the results of the statistical tests of the survey data. This part of the Chapter also includes findings made with regard to the survey results.

6.1. Response rate

The response rate achieved in each of the surveys was 68% and 48% for the Quality Framework and the Checklist respectively (Table 13).

Table 13: Survey target groups and response rate.

Survey topic	Population size	Sample size	Response rate (%)
Quality framework	25	17	68%
Checklist	40	19	48%

Saunders et al. (2009) provide guidance on population size selection. The lowest end of the guidance on population size is 50.

The population sizes, 25 and 40, in this study falls below the lower threshold of 50 but is limited by the scope available for study within the organisation. It is important to note that the target audience of the survey was first line managers, each responsible for a different department within the SOE that participated in the study. Therefore, as each member of the population represents an entire department a total population of 65 departments was selected and targeted for this study. Of these, 25 departments were made available for the pilot of the Quality Framework implementation method. Though this is below the prescribed population value of 50, the pilot involved a big organisational undertaking with 25 participating departments. The rest of the organisation uses the Checklist method. A sample of 40 departments was made available for the survey of the Checklist method.

Again, this is below the minimum recommended population size of 50; however, 40 department constitutes a large organisational area for investigation.

In this study sample size constitutes the number of responses received from each survey. Stutely (2003) recommends a minimum sample size of 30 per population group for statistical tests. Sample sizes of 17 and 19 were achieved for the Quality Framework and the Checklist implementation methods respectively (Table 13). As with the population size, despite sample size being below generally accepted limits, the sample size that was obtained through the survey constitutes responses from a total of 36 departments' from one organisation. This constitutes a substantial organisational undertaking. In industry, one would be hard pushed to obtain larger sample sizes of first-line managers than the samples sizes achieved in this study. For this reason, this research was deemed meaningful despite the limits on population and sample size.

Though it is not ideal that the population and size is below the 50 and 30 recommended by Saunders et al. (2009) and Stutely (2003) respectively, the value of being able to test the framework in a real organisational situation outweighs the un-ideal population and sample size. As mitigation, the limitations on population and sample size will be mentioned conclusions of the study.

Due to the low sample size and since De Winter & Dodou (2010) has found that in exceptional cases the Two sample t-test is more powerful in detecting Type II errors, it was decided to apply both the Two sample t-test and Mann-Whitney statistical tests to the results of the survey. By applying the two types of statistical significance tests it will provide interesting insight into which test's results should be given preference post an exception evaluation being done. The exception evaluation was performed according to prescriptions as set out by De Winter & Dodou (2010).

6.2. Significance testing

The data analysis framework as illustrated in Figure 17 was followed to analyse the primary data obtained by means of the surveys conducted for this study. The first step involved coding the data. This was done as described in Chapter 5.1. Subsequently, the coded data were tested for statistically significant differences using both the non-parametric Mann-Whitney test and the parametric Two-sample t-test. In evaluating the

results from these tests, an exception evaluation was conducted to determine if either of the tests results could be considered to be more powerful than the other.

The results of the statistical tests and the exception evaluations that were conducted are discussed in the subsequent Section s, Chapters 6.2.1. Findings made from the results are discussed in the Discussion of Results Section, Chapter 6.2.2.

6.2.1. Test results

Statistical tests conducted on the coded data yielded results as listed in Table 14. Refer to the Appendices Section of this document for the detailed results of the statistical tests applied to the survey responses. Appendix A contains the individual point plots. Appendix C and D contain the detailed results of the Two-sample t-test and Mann-Whitney test.

The test results were first analysed to look for statistically significant differences at a 95% confidence level. However, none of the test results yielded P-values below 0.05. Therefore, at a 95% confidence level, there is no difference between the responses for the Checklist method and the new Quality Framework.

Nevertheless, for the Two-sample t-test, Question 9 achieved a P-value below 0.1. Therefore, at a 90% confidence level, the null hypothesis can be rejected to find that there was a significant difference in means between the survey results for Question 9. In this case, the analysis for the Quality Framework produced a more favourable mean and median than that of the Checklist.

Questions 3 and 15 had P-values for the Two-sample t-test that were very close to the 90% confidence level. Though the results for the Mann-Whitney test were within the 80% confidence interval, it did not show the same proximity as the Two-sample t-test to the 90% confidence level.

The four results sets for the Mann-Whitney and the Two-sample t-test, with P-values that were closest to the 90% confidence interval for each test, was highlighted in Table 14.

In order to further explore the data, the survey responses were re-coded to a three-point scale. The reasoning behind this is discussed in Section 5.1. Refer to the Appendices Section of this document for the detailed results provided in Table 15. Appendix B

contains the individual point plots. Appendix E and F contain the detailed results of the Two-sample t-test and Mann-Whitney test.

Table 14: Statistical test results of survey responses on a six-point scale.

Coded scale	**1 to 6**					
Group/Test	**CL**	**QF**	**t-test**	**QF**	**CL**	**MW**
Statistical value	**Mean**	**Mean**	**P-Value**	**Median**	**Median**	**P-Value**
Question 1	*5,11*	*4,53*	***0,199***	*5*	*6*	***0,197***
**Question 2*	*3,47*	*3,18*	*0,429*	*3*	*3*	*0,447*
**Question 3*	*2,42*	*2,06*	***0,104***	*2*	*2*	***0,138***
**Question 4*	*2,95*	*2,47*	*0,221*	*2*	*3*	*0,266*
Question 5	4,74	4,74	0,939	5	5	0,973
Question 6	3,37	3,41	0,925	3	3	0,948
Question 7	4,68	4,76	0,862	5	5	0,934
Question 8	3,21	3,18	0,949	3	3	0,948
Question 9	4,26	4,88	**0,081**	5	4	**0,115**
Question 10	2,53	2,82	0,551	2	2	0,526
Question 11	4,58	4,88	0,395	5	5	0,430
Question 12	3,42	3,88	0,310	4	3	0,294
Question 13	4,53	4,77	0,519	5	5	0,762
Question 14	3,79	4,29	0,215	5	4	0,447
Question 15	4,00	4,71	**0,108**	5	4	**0,147**
Question 16	4,05	4,65	**0,155**	5	5	0,275

* Note that Question 2 to 4 is on a five-point scale
CL: Checklist
QF: Quality Framework
MW: Mann-Whitney test
t-test: Two-sample t-test
For detailed results see Appendix A, C and D

Note that Question 2 to 4 could not be re-coded to a three-point scale since the time-related questions had five options and not six. The recoded data was re-tested with the same tests. The results of these tests are listed in Table 15.

Similar to the results in Table 14, no test results yielded P-values below 0.05.

However, the Two-sample t-test produced a P-value of 0.068 for Question 9. This is well within the 90% confidence interval and very close to the 0.05 limit for a 95% confidence level. For Question 15, the P-values obtained for the tests on a three-point scale, 0.221 and 0.181 (Table 15), were further away from the 90% confidence level than the results for

the six-point scale at 0.108 and 0.147 (Table 14). In this case, test results for Question 15 do not contribute to confirming that there is a difference in the means or medians of this question.

Table 15: Statistical test results of survey responses on a three-point scale.

Coded scale	**1 to 3**					
Group/Test	**CL**	**QF**	**t-test**	**QF**	**CL**	**MW**
Statistical value	**Mean**	**Mean**	**P-Value**	**Median**	**Median**	**P-Value**
Question 1	*2,74*	*2,47*	***0,190***	*3*	*3*	***0,130***
Question 5	2,63	2,59	0,832	3	3	0,833
Question 6	1,95	1,94	0,982	2	2	0,987
Question 7	2,58	2,59	0,966	3	3	0,924
Question 8	1,79	1,77	0,927	2	2	1,000
Question 9	2,32	2,71	**0,068**	3	2	**0,107**
Question 10	1,47	1,59	0,646	1	1	0,558
Question 11	2,53	2,71	0,367	3	3	0,527
Question 12	1,84	2,18	0,208	2	2	0,213
Question 13	2,58	2,65	0,769	3	3	1,000
Question 14	2,16	2,47	0,230	3	2	0,342
Question 15	2,26	2,59	**0,181**	3	2	**0,221**
Question 16	2,37	2,53	0,491	3	3	**0,581**

CL: Checklist
MW: Mann-Whitney test
t-test: Two-sample t-test
QF: Quality Framework
For detailed results see Appendix B, E and F

It should be noted that De Winter & Dodou (2010) found there are exceptional cases where the 2-sample t-test has more power than the Mann-Whitney test. These exceptions manifest when a certain combination of data distributions are being compared and tested.

This evaluation was done for the results of Question 9, but it was not deemed necessary for the rest of the survey questions. This is because, out of all the questions that were considered potentially significant (Question 3, 9 and 15), it is the only result set where the results for the Two-sample t-test and Mann-Whitney test fell within different confidence intervals. For instance, from Table 14, results for the Mann-Whitney test were within the 85% confidence interval whereas results for the Two-sample t-test was within the 90% confidence level. Since it is known from the study by De Winter & Dodou that there are cases where the Two-sample t-test is more powerful in terms of detecting Type II errors,

the results from Question 9 were selected to undergo an exception evaluation to determine which results should be favoured.

The skewness values for the sample distributions for Question 9 are given in Table 16.

Table 16: Skewness values for Question 9

Coded scale	**1 to 6**		**1 to 3**	
Group	**Checklist**	**Quality Framework**	**Checklist**	**Quality Framework**
Skewness	-0.79	-0.43	-0.01	-0.95
The shape of the sample distribution	Multimodal	Agree flat	Strong multimodal	Multimodal

The shape of the sample distributions for Question 9 was evaluated to see if it falls within these exceptional cases. De Winter & Dodou provides the matrix as illustrated Table 18 to determine which significance test has more power for certain combinations of data distribution skewness values. The number above the diagonal represents the probability percentage of Type II errors for the Two-sample t-test. Below the diagonal is the difference in Type II error probability between the Mann-Whitney and the Two-sample t-test. As per the note, a positive number below the diagonal indicates that the Two-sample t-test is more powerful than the Mann-Whitney test.

Population distributions for Question 9 were established by comparing the skewness value for the results of this study (Table 16) to the study performed by De Winter & Dodou (Table 17). By looking up the pairs of sample distributions for the six-point scale, “Multimodal” and “Agree flat”, it was determined that the Two-sample t-test was not more powerful than the Mann-Whitney test. However, for the three-point scale, it can be seen that the Two-sample t-test *is* more powerful than the Mann-Whitney test for the combination of “Stong multimodal” and “Multimodal” distributions with a value of “4” below the diagonal. Therefore, for this scale, test results from the Two-sample t-test should be favoured over the results for the set for the Mann-Whitney test. Note that the sample size in Table 18 was 10 for both sets. This compares reasonably well with the sample size of this study, of 17 and 19.

Table 17: Skewness and kurtosis values for population distribution used for study by De Winter & Dodou (Five-Point Likert Items: t-test versus Mann-Whitney-Wilcoxon (2010))

	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	*SD*	Skewness	Kurtosis
Very strongly agree	0	1	3	6	90	4.85	0.50	-3.70	17.03
Strongly agree	1	3	6	30	60	4.45	0.82	-1.76	6.35
Agree peak	5	10	20	45	20	3.65	1.07	-0.77	3.08
Agree flat	10	15	20	30	25	3.45	1.29	-0.46	2.12
Neutral to agree	10	20	30	25	15	3.15	1.20	-0.11	2.15
Neutral peak	0	20	50	20	10	3.20	0.88	0.51	2.68
Neutral flat	15	20	25	20	20	3.10	1.34	-0.06	1.86
Very strongly disagree	80	12	4	3	1	1.33	0.78	2.70	10.19
Strongly disagree	70	20	6	3	1	1.45	0.82	2.09	7.29
Disagree flat	25	35	20	15	5	2.40	1.16	0.53	2.37
Neutral to disagree	10	25	30	20	15	3.05	1.21	0.08	2.10
Certainly not disagree	1	4	50	30	15	3.54	0.83	0.19	2.91
Multimodal	15	5	15	25	40	3.70	1.42	-0.83	2.37
Strong multimodal	45	5	0	5	45	3.00	1.93	0	1.06

Note. The kurtosis of a normal distribution is 3. Distributions that are more outlier-prone than a normal distribution have kurtosis greater than 3; distributions that are less outlier-prone have kurtosis less than 3.

Table 18: Power comparison for Two-sample t-test and Mann-Whitney test (Five-Point Likert Items: t-test versus Mann-Whitney-Wilcoxon (2010))

		Type II errors														Type I errors	
		Very strongly agree	*Strongly agree*	*Agree peak*	*Agree flat*	*Neutral to agree*	*Neutral peak*	*Neutral flat*	*Very strongly disagree*	*Strongly disagree*	*Disagree flat*	*Neutral to disagree*	*Certainly not disagree*	*Multimodal*	*Strong multimodal*		
	$n = m = 10$	1	2	3	4	5	6	7	8	9	10	11	12	13	14	*t* test	MWW
1.	*Very strongly agree*		75	12	12	3	1	4	0	0	0	2	5	34	21	0.8	0.9
2.	*Strongly agree*	-6		54	49	25	16	28	0	0	2	20	36	75	48	4.4	5.1
3.	*Agree peak*	-5	-5		93	83	80	83	1	1	36	78	93	94	86	5.1	5.1
4.	*Agree flat*	-3	1	0		91	90	91	3	5	56	88	94	92	91	5.3	5.4
5.	*Neutral to agree*	-1	-1	0	0		95	95	6	9	72	94	88	84	94	5.0	4.9
6.	*Neutral peak*	0	-2	-4	-2	0		94	2	3	61	94	86	81	94	5.1	5.1
7.	*Neutral flat*	-1	2	1	0	0	-1		9	13	77	95	88	83	94	5.1	5.1
8.	*Very strongly disagree*	0	0	0	0	-2	-1	-2		95	35	8	0	3	36	2.2	3.3
9.	*Strongly disagree*	0	0	0	0	-1	-1	0	-2		46	11	1	4	43	4.1	5.3
10.	*Disagree flat*	0	0	0	0	0	-2	0	-8	-4		78	34	45	87	5.1	5.2
11.	*Neutral to disagree*	0	1	0	0	0	0	0	-3	-2	0		83	79	94	5.3	5.4
12.	*Certainly not disagree*	-2	-5	-2	-1	1	-1	0	0	0	1	0		91	89	5.1	5.3
13.	*Multimodal*	-6	3	-2	-1	-3	-6	-1	1	2	1	-3	-4		85	4.9	4.9
14.	*Strong multimodal*	6	21	4	0	-2	-3	-2	11	16	2	-3	1	4		5.0	5.3

Note. A positive number below the diagonal means that the *t* test was more powerful than MWW.

6.2.2. Discussion of Results

In this Section, the results of the significance tests conducted will be discussed. Specifically, this discussion will be done for Question 3, 9 and 15, as summarised in Table 19, since out of all the survey questions, these questions had the most significant results. The result set for each question will be plotted on a scale to illustrate in which confidence interval the results fell in. From this comparison, the level of significance and merits of each result set will be discussed. Apart from the questions mentioned above, there will be a discussion around the remainder of the survey results that did not achieve significance.

As further context for the results, the limitations of the research are listed below. The result discussion should be read in the context of these limitations:

- The research was conducted in one organisation.
- The sample sizes were limited to 17 and 19, which is below the generally accepted minimum of 30. However, the undertaking is representative of a major portion of the participating organisation's departments.

Table 19: Summary of P-values that bear potential significant results

Statistical value	**P-value**			
Coded scale	**Six-point scale**		**Three-point scale**	
Significance test	**MW**	**t-test**	**MW**	**t-test**
Question 3: On average, what amount of time do you in person spend on maintaining the "Quality Framework"/"Checklist"?	0.138	0.104	-	-
Question 9: The "Quality Framework"/"Checklist" provides useful methodologies to assist my department to perform better.	0.115	0.081	0.107	0.068
Question 15: The Quality Framework/Checklist has positively changed how I think about my operations."	0.147	0.108	0.221	0.181

6.2.2.1. Question 9 results

Since Question 9 achieved the most significant results as summarised in Table 19, it will be discussed first. Figure 18 shows the results for this question plotted on a confidence interval scale. Take note of the following aspects from this figure:

- Points B and D: Results of the Two-sample t-test found that there was a statistically significant difference between the means of the two sample groups within a 90% confidence interval. Note that this is the case for the Two-sample t-test for both the six- and three-point scales.
- Point D: The P-value for the Two-sample t-test on the three-point scale was close to the lower limit of the 95% confidence interval but did not technically fall within that interval.
- Points A and C: Though the P-values for the Mann-Whitney test were very close to the lower limit for the 90% confidence interval, it did not technically fall within that confidence interval.

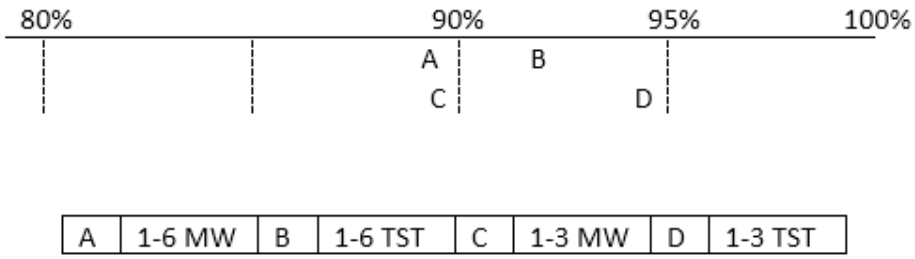


Figure 18: Confidence interval of significance test results for Question 9

The statistically significant difference in mean, for all the tests and scales applied to Question 9, was in favour of the Quality Framework.

From the exception evaluation for Question 9, it was found that:

- Points A and B: On the six-point scale, the exception evaluation did not indicate that the Two-sample t-test is more powerful than the Mann-Whitney test. Therefore it is concluded that results for Points A and B are equal in power.
- Points C and D: For the survey responses that were re-coded on a three-point scale, the Two-sample t-test is more powerful than the Mann-Whitney test. Point D represents the result of the more powerful test as opposed to Point C.

Thus, for the three-point scale it can conclusively be said that there is a statistically significant difference in the means of results within a confidence interval of 90%, Point D. This is supported by the result on the six-point scale (Point B), though for the same scale

the Mann-Whitney test result (Point A) was close to but not strictly inside the 90% confidence interval.

An inference by Hazelrigg, in literature by Hardy & Bryman (2004), provides insights into confidence intervals. Hazelrigg asserts that confidence intervals should be chosen at a level that is acceptable to the researcher and the audience of the research. In the case of high-risk research projects, such as health or environmental research, where errors in test results can have dire consequences, results within a 95% or even 98% confidence interval would be considered acceptable. For this study, a 90% confidence interval can be accepted as sufficient. Though undesired, in the unlikely event of an error in the findings of these results (10% probability), the consequences of error will not threaten lives or the environment. By declaring the limitations within which the test results were obtained, the results of Question 9 for the Two-sample t-test may be accepted as statistically significant and subsequent conclusion may be drawn within a confidence interval of 90%.

Question 9 had wording as illustrated in Table 19. From the significance test results, in comparison to the Checklist, this study finds that the Quality Framework is superior in providing performance improvement methodologies within a 90% confidence interval.

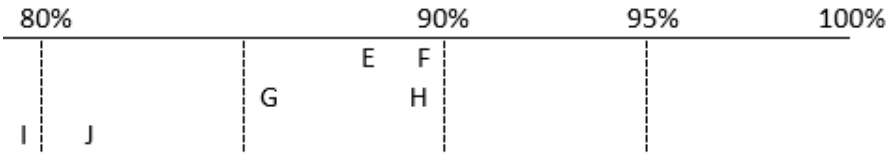
This finding is consistent with the aims of the framework. The framework, which is in a diagram or process flow format, provides methodologies as to how to apply and internalise the requirements of the standard into the operations of a department. Therefore, as intended in the design of the framework, it suites the “Plan/Development” and “Do/Implementation” phases of a management system adoption process (Figure 5, pg. 33).

Furthermore, from a more detailed point of view, improvement methodologies are provided by the following aspects of the Quality framework. Through the methodology provided for effectively documenting customer needs, the operations or a department/organisation can be shaped to continually improve on service or product provision to internal or external customers. Through the methodology provided for identifying influencing factors, these factors can be translated into opportunities and risks. Opportunities to improve on service or product provision can be realised. Risks can be mitigated to ensure quality and continuity of supply.

In contrast, the nature of the Checklist is such that it is aimed at checking compliance. It is not geared towards providing methodologies to achieve a specific goal, such as performance improvement in this case. Rather the Checklist serves as an aid to auditors during the checking phase of an implementation. It is, therefore, more suited to the "Check/Audit" phase of the management system adoption process flow. However, ironically the checklist is widely used in the "Plan/Development" and "Do.Implementation" phases. In effect, by making use of a Checklist for implementation, managers are required to use a method, suited to the "Check/Audit" phase, in the "Plan/Development" and "Do/Implementation" phases. Therefore, it makes sense that managers would find the framework more useful in providing improvement methodologies when compared to the Checklist.

6.2.2.2. Question 3 and 15 results

Next, the results for Question 3 and 5 will be discussed. As with Question 9, the results are plotted on a confidence interval scale as can be seen in Figure 19. Take note that for Question 3 and 15 the results for the Two-sample t-test, Points F and H on Figure 19, were within a very small margin of the 90% confidence interval on the six-point scales. The actual P-values of the test results are listed in Table 19 for reference. However, this was not the case for Points E, G, I and J, the remainder of the results for Question 3 and 15.



Question 3			
E	1-6 MW	F	1-6 TST

Question 15							
G	1-6 MW	H	1-6 TST	I	1-3 MW	J	1-3 TST

Figure 19: Confidence interval of significance test results for Question 3 and 15

The nature of research is such that it is a snapshot of a real situation (Saunders, Lewis and Thornhill, 2009). For results that are within a small margin of being significant, it has merit to not discard these results since, in a duplicated study, it is quite possible that results for the same questions might fall within a range that can be considered as significant. Because of the proximity of the results of Question 3 and 15 to the 90% confidence interval for Two-sample t-test, Points F and H, it is worth including these results in this discussion of the survey results, but to do so within the context of the limitations that apply to the results.

Question 3 could not be re-coded to a three-point scale since it was on a five-point scale in the survey. Details around the scale selection for the time related questions are given in Section 4.3.3. Therefore, the result could not be further explored or confirmed on another scale. Within these limitations, the Two-sample t-test results for Question 3 will be discussed. Take note of the wording of Question 3 in Table 19. This Question is concerned with the time spent maintaining a QMS that was either implemented by means of the Checklist or the Quality Framework. In this case, a lower mean could indicate that an ISO 9001:2015 implementation using the Quality Framework takes less time to maintain. Therefore, a lower mean is considered positive. The difference in the mean, therefore, is again in favour of the Quality Framework.

Within the limitations on the results from Question 3, this study finds that the Quality Framework might potentially take less time to maintain than a system implemented by means of the Checklist.

Once certification has been completed, and all gaps identified as part of Step 1 to 10 of the Quality Framework have been closed, only Step 11 to 14 need to be maintained on a periodical basis (Figure 16, pg. 48). This is because these steps represent aspects of a QMS that is variable over time. For instance, influencing factors leading to opportunities and risks change over time due to opportunities and risks being address and due to changes in the environment in which an organisation exists. Therefore, these aspects need to be periodically reviewed and updated. Steps 11 to 14 represent a small portion of the steps that make up the framework. Therefore, though it is anticipated that the framework will take some time to implement, the maintenance of it is low. In contrast, for the Checklist implementation method, the entire list of requirements needs to be reviewed on a periodical basis. Therefore, the aspects discussed above support the test results of

Question 3 so as to say that it is probable that managers spend less time maintaining the Quality Framework as opposed to the Checklist implementation method.

Next, the results for Question 15 will be discussed. Consider Points G and H in comparison with Points I and J in Figure 19. Subsequent to obtaining the results for Question 15 for the six-point scale, the data was re-coded to a three-point scale and re-tested. However, in this instance, re-coded results for three-point scale (Points I and J) were further away from the 90% confidence interval than results of the six-point scale (Points G and H). Therefore, the proximity of the initial Two-sample t-test results to the 90% confidence interval (Point H) could not be confirmed for the same test on the three-point scale (Points I and J). Notwithstanding the failure to affirm the six-point scale results of the Two-sample t-test on the three-point scale, the result for the six-point scale is still close enough to the 90% confidence interval that it bears including it in this discussion within the limitations observed.

For Question 15, the difference in means of the Two-sample t-test on the six-point scale (Point H) is in favour of the Quality Framework. Therefore, within the limitations stated above, this study finds that the Framework is possibly more compelling than the Checklist in positively influencing how managers think about their operations.

The topic for Question 15, is closely related to the topic of Question 9. Since the framework has a strong operational focus it makes sense that it would bring a new positive perception about amongst managers on their view of their operations. The framework is designed with managers' needs in mind whereas the Checklist, as previously mentioned, is geared towards the needs of auditors since in actual fact it is an audit phase aid. Therefore, it is possible that the Quality Framework has a stronger effect in terms of creating a positive perception amongst managers regarding their operations in comparison to the Checklist implementation method.

6.2.3. Remainder of the questions

The rest of the survey questions did not yield results that could be considered significant. Therefore, no conclusions are drawn with regards to these questions. The lack of statistical significance in the remaining questions of the survey might be attributed to low sample size, but this is not confirmed. However, on the whole, the survey results did not yield any negative findings with regards to the use of the Quality Framework. Therefore,

the Quality Framework does achieve the same goal of implementing ISO 9001:2015 requirements as the Checklist yet managers find the Quality Framework more useful.

Consider the breakdown of the survey result means and which implementation method it was in favour of, as illustrated in Figure 20. These graphs exclude results for Likert Questions 9 and 15 since it has already been discussed and taken into account. In addition, it excludes the time-related questions. From the graphs, it can be seen that the remainder of the Likert survey results reflects the same favour in result means towards the Quality Framework as the results for Question 9 did. Though not found to show statistical significance, the remainder of the survey questions is consistent with results for Question 9, which was found to be statistically significant within a 90% confidence interval (Figure 20). Therefore, it serves as encouragement for further development and study of the Quality Framework.

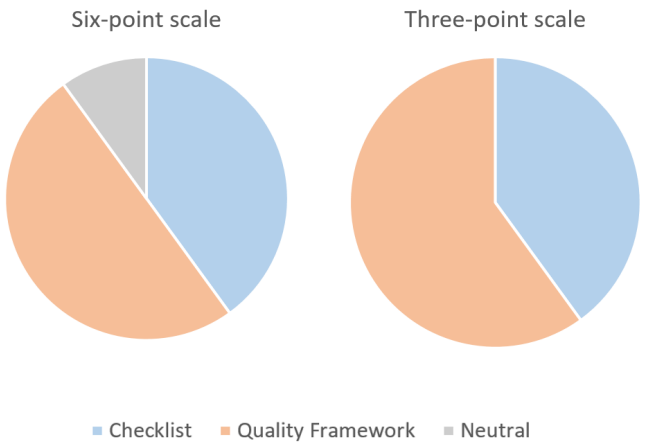


Figure 20: Implementation method favoured in terms the means achieved for the survey results (Excludes results for Question 9 and 15)

6.3. Summary of Results

Though the survey population and sample sizes are below minimum requirements it is important to note that the survey represents a substantial organisational endeavour and captures real-life responses directly from industry. Therefore, the opportunity to test the Quality Framework in a real-life set-up outweighs the limitations on population and sample sizes achieved. From the survey results, one question yielded a result that was within the 90% confidence interval and two questions were within a small margin of being significant. The set of these three results were all in favour of the Quality Framework. Furthermore, the majority of the results that did not fall within a 90% confidence interval were also in

favour of the Quality Framework. This serves as motivation to perform further studies on the use of the Quality Framework as implementation method

Chapter 7

Conclusions and Recommendations

As set out in Chapter 1, objectives were set with regards to the research problem being investigated in this study. For ease of reference, the research question and associated objectives are again listed in Table 20. In this Chapter, the means by which the objectives were met will be discussed. Conclusions will be drawn from findings pertaining to the survey results. In addition, conclusions will be made on whether the objectives were met and the research question was answered.

7.1. Conclusions

As illustrated in Table 20, the first objective of this study was met through the development of the implementation framework, namely the Quality Framework. Internalisation is promoted by having the process approach, which represents the operations of a department, as the central point of the framework. In turn, a customer focus is facilitated effectively through the dedicated steps for customers and interested party needs. Further requirements are covered by linking the remainder of the generic requirements to the activities of a department in a systematic way.

As intended in Objective 1, the framework is novel in terms of the format in which it presents ISO 9001:2015 requirements with regards to the following aspects:

- It consolidates and summarises the generic requirements of the standard into one diagrammatic framework illustrating the interaction of the standard's requirements with the operations of a department.
- It is in an interactive multimedia format that is editable for leadership to populate with the particulars of their department.

Table 20: Fulfilment of research question and objectives

Research Question	Research objectives	Was the requirement met?	Details on the fulfilment of the requirement
Can implementation of ISO 9001:2015 requirements be facilitated better through the utilisation of a flowchart implementation framework?	**Objective 1:** Develop a novel implementation framework for ISO 9001:2015 by presenting requirements in an editable flowchart format.	Yes	A framework was developed that is in a diagrammatic format. The framework encompasses the process approach, facilitating a customer focus and activity related requirements. It is editable and interactive for the user to populate with information from their own environment.
	Objective 2: Determine the effect of the novel implementation framework on manager's perception and attitude towards ISO 9001:2015 in comparison to the effect of the Checklist implementation method.	Yes	By means of the survey conducted for this study, data was collected and analysed pertaining to managers' attitude towards ISO 9001:2015 and the implementation method used. Findings included one significant and two potentially significant areas of influence.

Ironically, despite ISO being a process driven standard, it is still widely being implemented with the Checklist implementation method. The Quality Framework provides an alternative to the Checklist for the adoption of ISO 9001:2015 requirements. In light of the aspects discussed above, it is safe to say that Objective 1 was met through the Quality Framework that was produced as part of this research project.

Next, the merits of the Quality Framework will be discussed in fulfilment of Objective 2 (Table 20). The survey was designed to measure managers' attitude towards ISO 9001:2015 and the implementation method used. The survey covered the following topics:

- Time and effort
- Attitude in general
- Value
- Integration and effectiveness

From findings pertaining to the survey results discussed in Chapter 6.2.2, the following conclusions could be drawn in favour of the Quality Framework. The Quality Framework in comparison with the Checklist implementation method:

- Is superior in terms of providing business improvement methodologies to assist departments in their quest to improve performance.
- Is potentially less effort to maintain than the Checklist implementation method.
- Potentially influences the way managers think about their operations in a positive way.

Limitations on these conclusions are as follows:

- Population size achieved is below the minimum prescribed by Saunders et al. (2009)
- Sample size achieved is below the minimum prescribed by Stutely (2003)

However, the organisational pilot and survey performed as part of this study did provide the opportunity to test the Quality Framework in a real-life situation. The value of being able to test the proposed framework in a real-life situation outweighs the limitations in terms of population and sample size.

These conclusions pertain to the findings made with regards to Question 9, 3 and 15 respectively. For the remainder of the questions, statistical significance could not be confirmed, though the majority of the means of the questions were in favour of the Quality Framework. Therefore, though no conclusions could be made in this regard, it does serve as encouragement for further development and study of the Quality Framework.

Furthermore, with regards to the first of the conclusions discussed above, it can be asserted that since the Quality Framework is superior in providing business improvement methodologies that the framework constitutes knowledge transfer best practice. This is consistent with findings by Ainsworth & Loizou (2003) and Ollerenshaw et al. (1997). The last of these points suggests an enhanced awareness among managers of their operations in the context of ISO 9001:2015 requirements. Therefore, it supports the notion that the Quality Framework promotes internalisation. This is in agreement with findings by Allur et al. (2014) that improved internalisation promotes organisation value.

The survey and subsequent analysis of the results were successful in determining the effect of the framework on managers' perception in the context of ISO 9001:2015. It is therefore concluded that Objective 2 was effectively met.

From the conclusions discussed as part of this Chapter, it is recommended that the Quality Framework be used for the implementation of ISO 9001:2015 requirements.

7.2. Contributions to literature

Despite the benefits of ISO 9001 being well established, there remains a gap in literature on how to overcome barriers to the sustainable implementation of ISO 9001. Recall that leadership's understanding and attitude towards ISO 9001 is critical for a successful implementation of the standard (Yeung, Lee and Chan, 2003). As part of this study, a significant finding was made pertaining to leadership's attitude and understanding of ISO 9001:2015 implementation methods. This refers to the findings made with regards to Question 9. Therefore, this study makes a valuable contribution to filling the gap in overcoming barriers to sustainable implementation.

Not much is written on the topic of IS0 9001 implementations within the South African context. This research project was conducted at a South African SOE. It therefore provides insights into ISO 9001:2015 within the South African context, contributing to the limited body of knowledge on the topic in this context.

Since there is a gap in literature on overcoming barriers to sustainable implementation, it follows that there is also a gap in terms of a means to study implementation method improvement initiatives. In this study, the methodology followed in terms of developing the Quality Framework and testing it by means of a Likert style survey provides a basis for similar studies in future. In this way, the project contributes to literature by developing and defining a process for the development and testing of projects pertaining to the improvement of implementation methods.

7.3. Recommendations for Future Work

The findings and conclusions made with regards to the survey results provide an incentive for the Quality Framework to be further developed and studied. In light of this, three recommendations are made in terms of future work to follow on this research project:

1. Duplicate the same study in another industry.
2. Perform a maturity and longevity study.
3. Expand the same approach to other ISO management system standards.

Though the pilot and survey were conducted within a SOE, the framework is generic in nature and therefore applies to all industries. To provide further confidence in the findings obtained from this study, it is recommended that the same study is duplicated in another industry and compared to the results of this study.

This study investigated the use of the Quality Framework within a limited time span, but it might be interesting to investigate how the systems that were tested matured over time. Evidence of superficial implementations might only realise years after implementation has been completed. Therefore, a maturity and longevity study is recommended. A year or two after implementation, the same approach can be used where leadership is subjected to a Likert style survey. Alternatively, an audit with the specific focus of testing internalisation can be conducted. Re-certification might offer an opportune time to perform this follow up study.

Consider the principle that improved internalisation of ISO 9001 requirements yields more organisational value (Allur, Heras-Saizarbitoria and Casadesús, 2014). It follows that the same principle would apply to the other management system standards as well. This is because all of these standards have adopted the same high-level structure and have the process approach in common. Therefore the implementation framework development methodology followed in this study has great potential to assist with the same task for the other ISO management system standards. It therefore offers the opportunity to extend implementation best practice put forward in this study to other ISO management system standards as well.

In light of this, it is recommended that the framework development and testing process established and followed in this study (Figure 1, pg. 15) be applied to the following management system standards:

- ISO 14001: Environmental Management System Standards
- OHSAS 18001: Occupational Health and Safety Management System Standard
- ISO 27001: Information security Management System Standard
- ISO 55001: Asset Management System Standard

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Appendix A:

Individual value plot, six-point scale

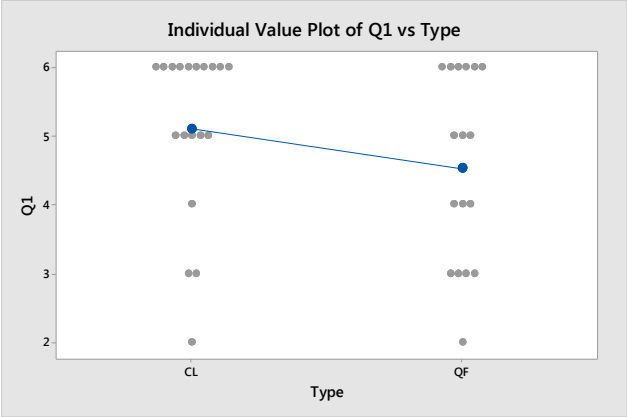

Figure A 1: Individual value plot for Question 1 on a six-point scale

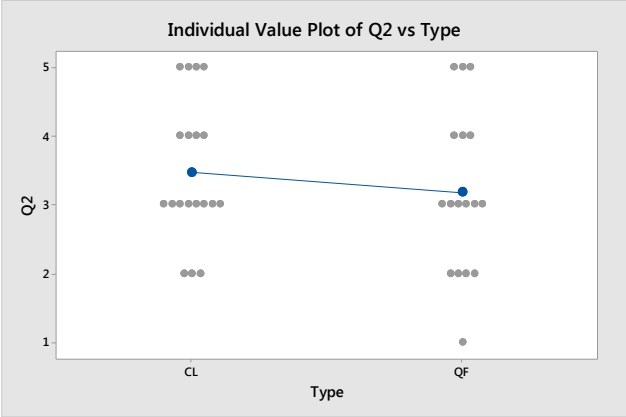

Figure A 2 Individual value plot for Question 2 on a six-point scale

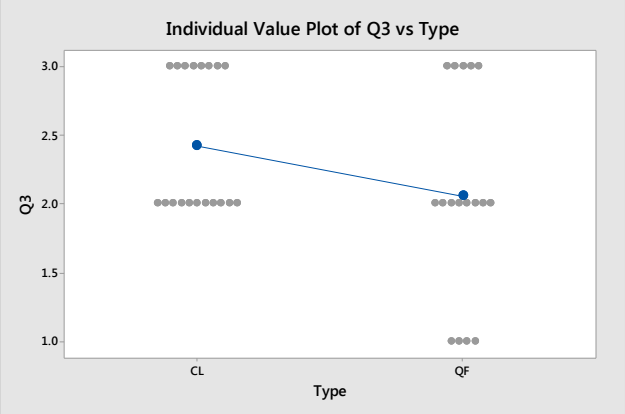

Figure A 3 Individual value plot for Question 3 on a six-point scale

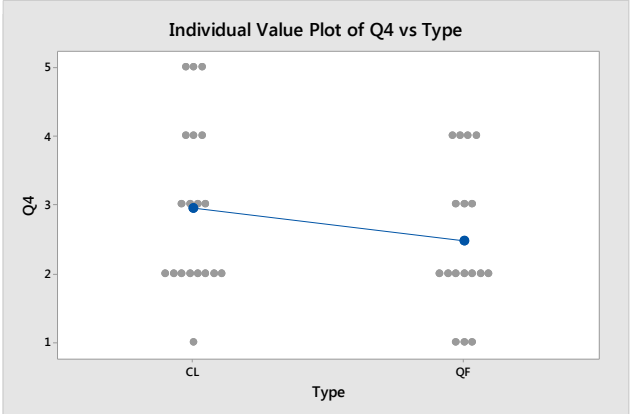

Figure A 4 Individual value plot for Question 4 on a six-point scale

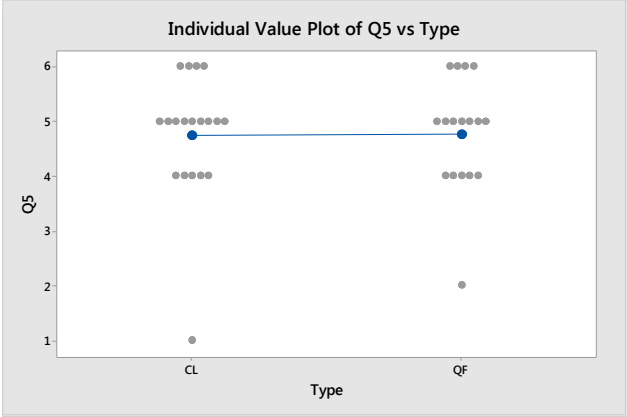

Figure A 5 Individual value plot for Question 5 on a six-point scale

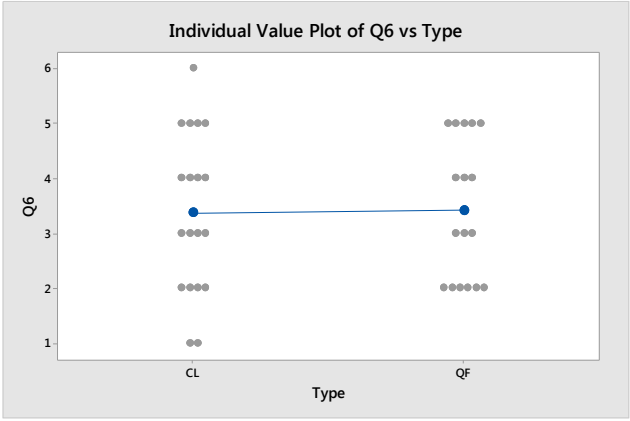

Figure A 6 Individual value plot for Question 6 on a six-point scale

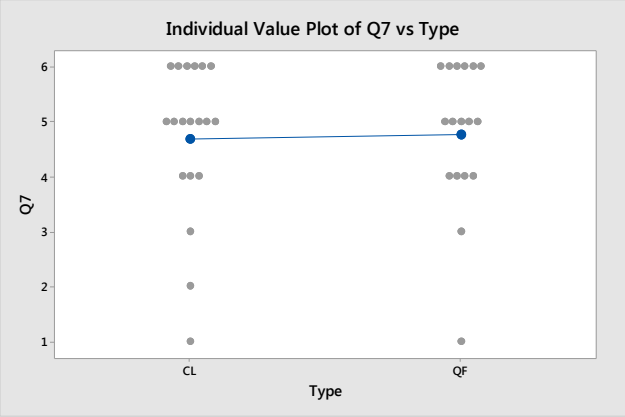

Figure A 7: Individual value plot for Question 7 on a six-point scale

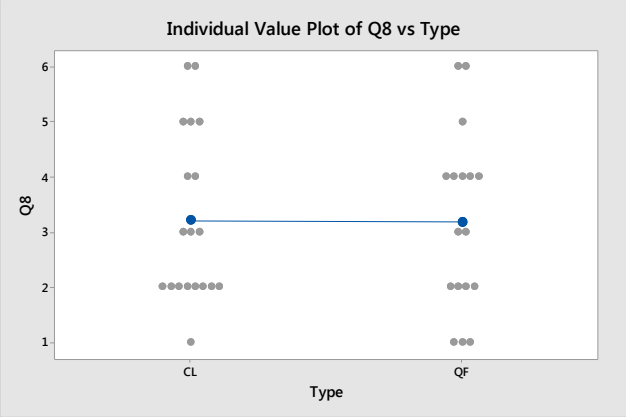

Figure A 8 Individual value plot for Question 8 on a six-point scale

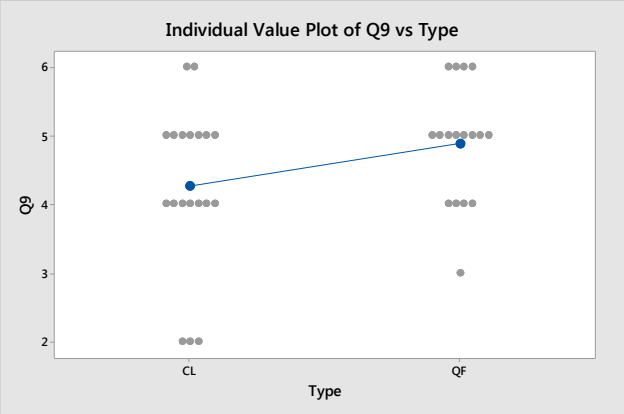

Figure A 9 Individual value plot for Question 9 on a six-point scale

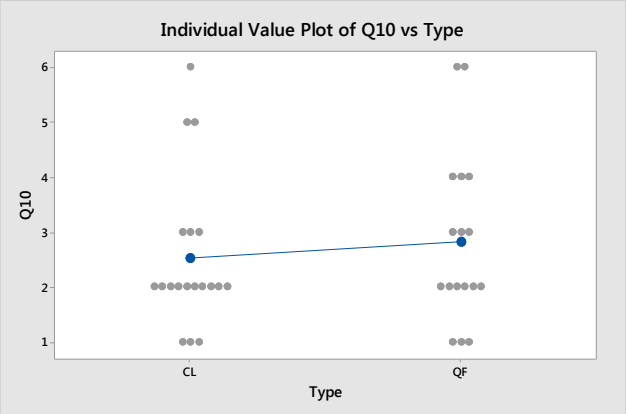

Figure A 10 Individual value plot for Question 10 on a six-point scale

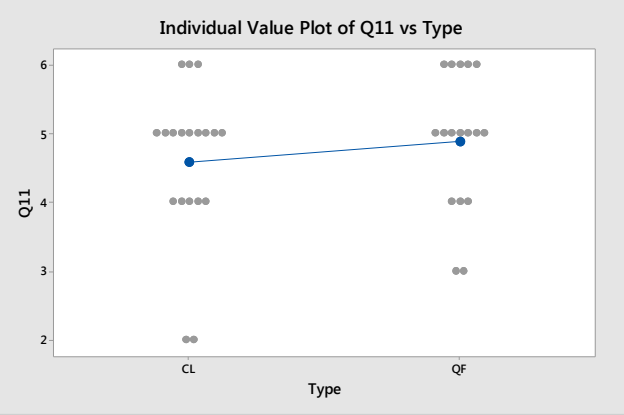

Figure A 11 Individual value plot for Question 11 on a six-point scale

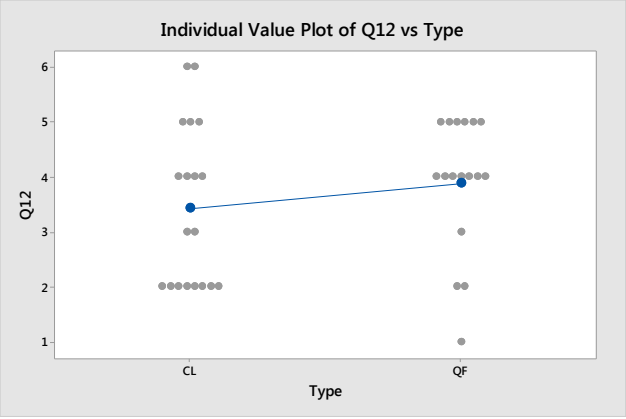

Figure A 12 Individual value plot for Question 12 on a six-point scale

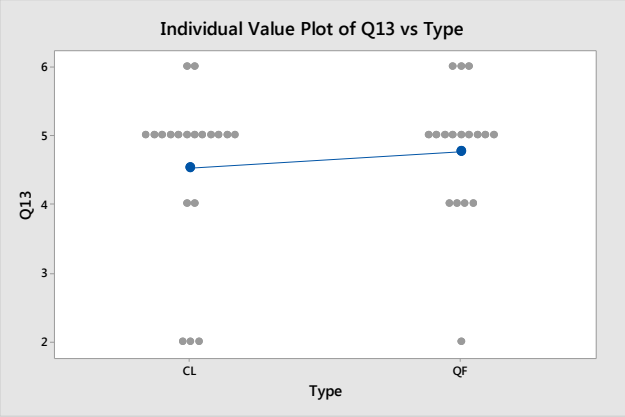

Figure A 13: Individual value plot for Question 13 on a six-point scale

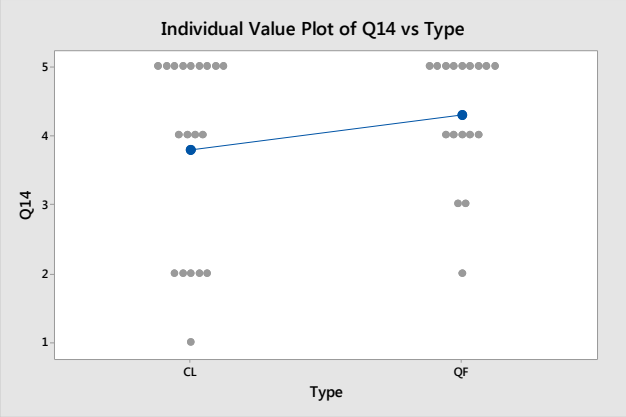

Figure A 14 Individual value plot for Question 14 on a six-point scale

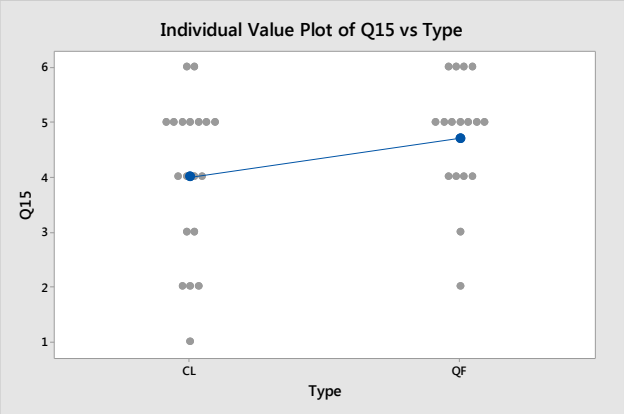

Figure A 15 Individual value plot for Question 15 on a six-point scale

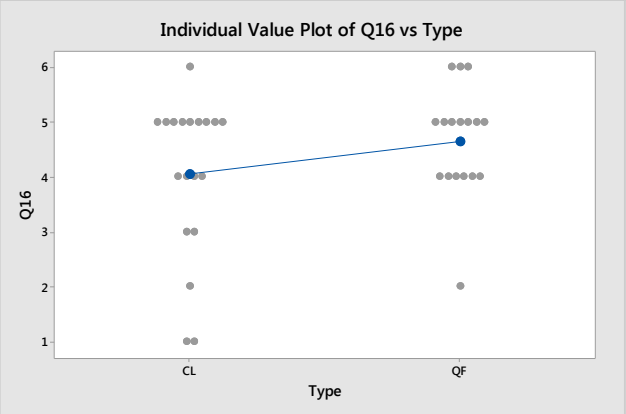

Figure A 16 Individual value plot for Question 16 on a six-point scale

Appendix B:

Individual value plot, three-point

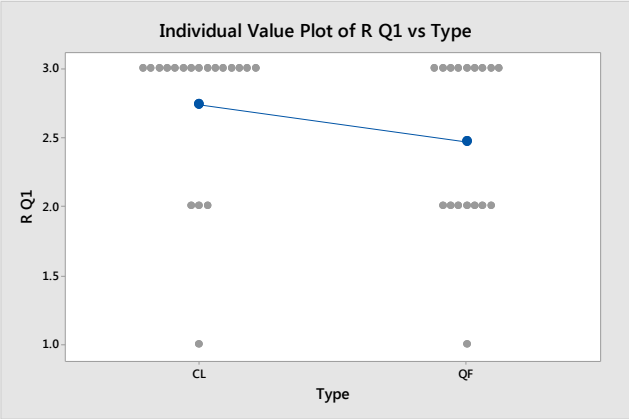

Figure B 1: Individual value plot for Question 1 on a three-point scale

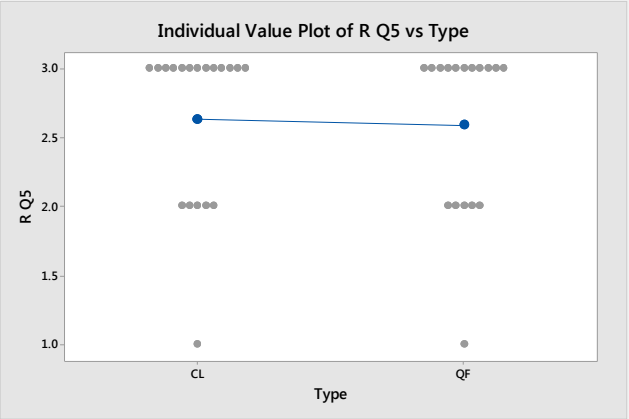

Figure B 5: Individual value plot for Question 5 on a three -point scale

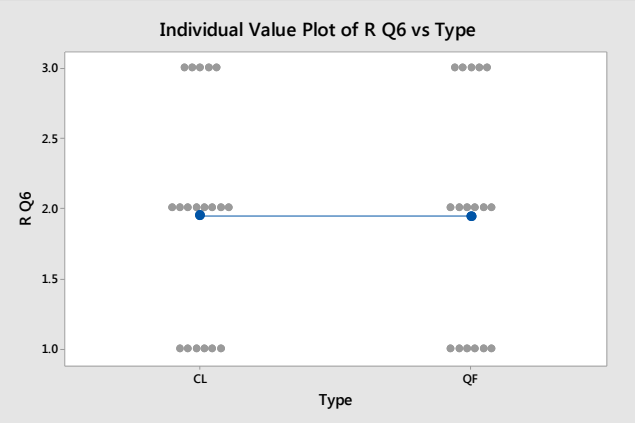

Figure B 6: Individual value plot for Question 6 on a three -point scale

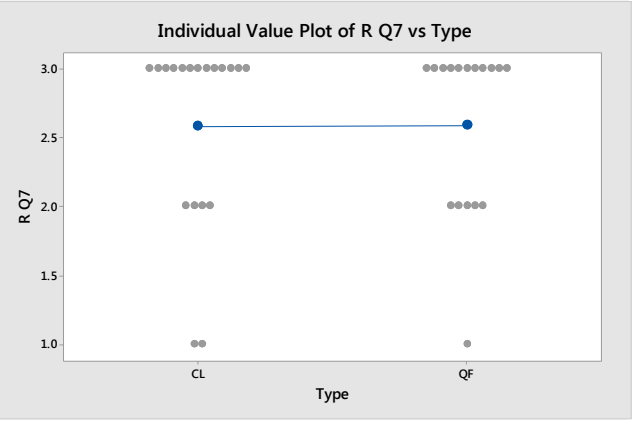

Figure B 7: Individual value plot for Question 7 on a three -point scale

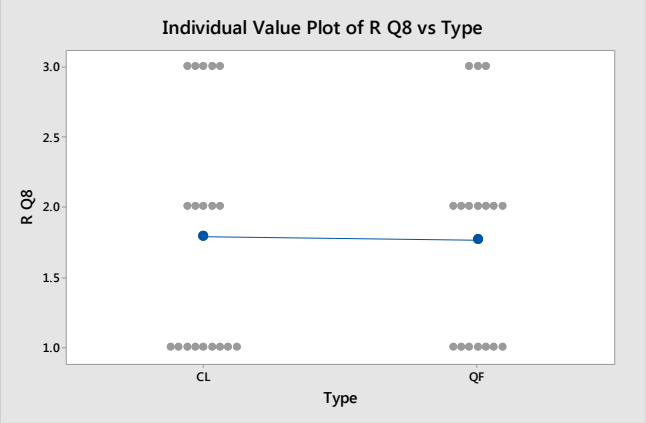

Figure B 8: Individual value plot for Question 8 on a three -point scale

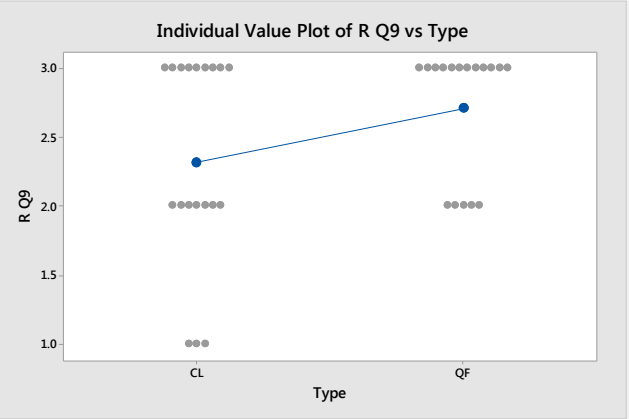

Figure B 9: Individual value plot for Question 9 on a three -point scale

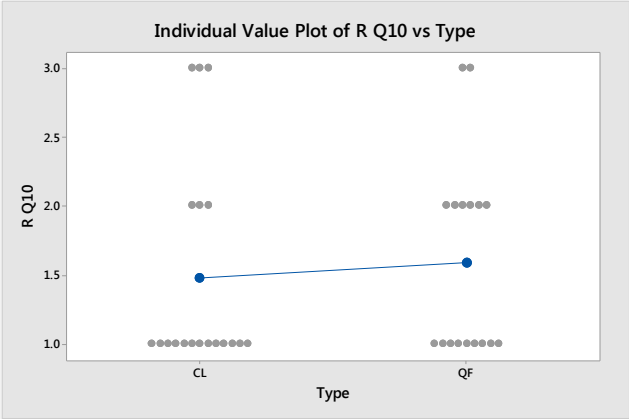

Figure B 10: Individual value plot for Question 10 on a three -point scale

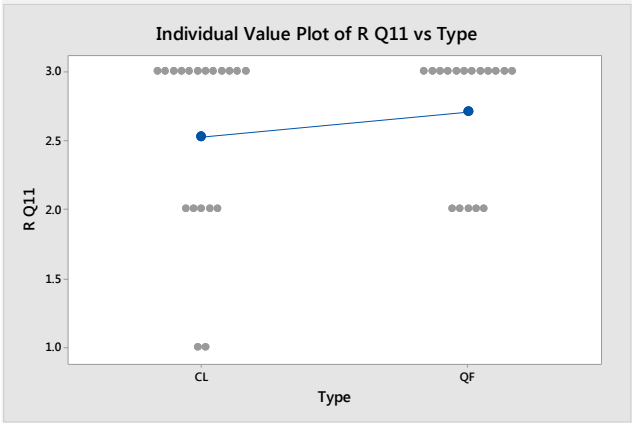

Figure B 11: Individual value plot for Question 11 on a three -point scale

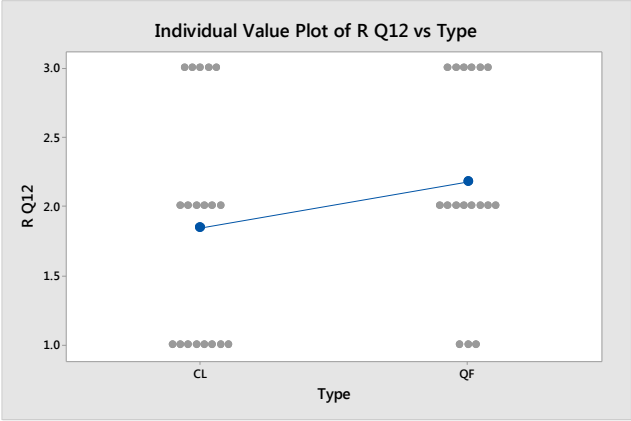

Figure B 12: Individual value plot for Question 12 on a three -point scale

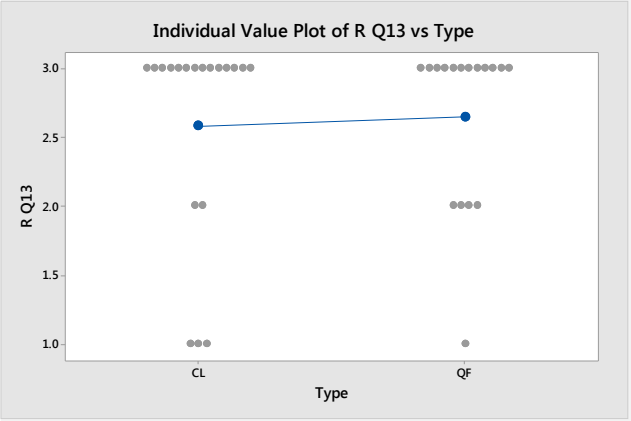

Figure B 13: Individual value plot for Question 13 on a three -point scale

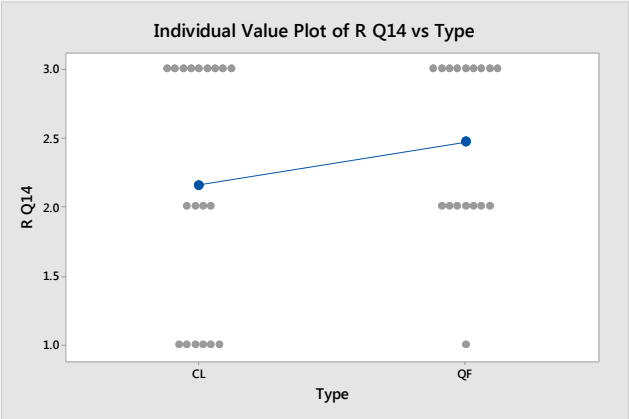

Figure B 14: Individual value plot for Question 14 on a three -point scale

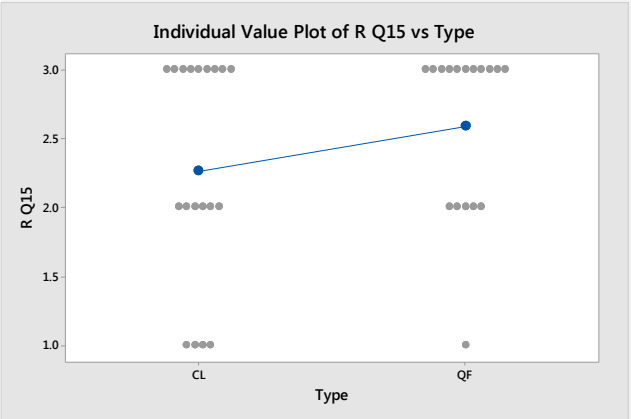

Figure B 15: Individual value plot for Question 15 on a three -point scale

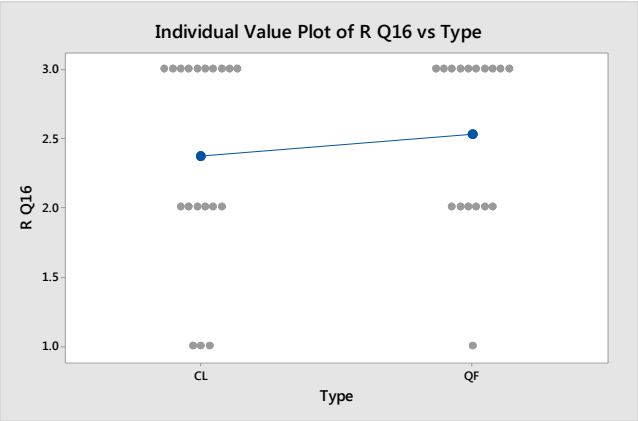

Figure B 16: Individual value plot for Question 16 on a three -point scale

Appendix C:

Two-sample t-test, Six-point scale

Two-Sample T-Test: Question 1

Method

μ_1: mean of Q1 when Type = C
μ_2: mean of Q1 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q1

Type	N	Mean	StDev	SE Mean
CL	19	5.11	1.24	0.29
QF	17	4.53	1.37	0.33

Estimation for Difference

Difference	95% CI for Difference
0.576	(-0.318, 1.469)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
1.31	32	0.199

Two-Sample T-Test: Question 2

Method

μ_1: mean of Q2 when Type = CL
μ_2: mean of Q2 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q2

Type	N	Mean	StDev	SE Mean
CL	19	3.47	1.02	0.23
QF	17	3.18	1.19	0.29

Estimation for Difference

Difference	95% CI for Difference
0.297	(-0.459, 1.053)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value

0.80	31	0.429

Two-Sample T-Test: Question 3

Method

μ_1: mean of Q3 when Type = CL
μ_2: mean of Q3 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q3

Type	N	Mean	StDev	SE Mean
CL	19	2.421	0.507	0.12
QF	17	2.059	0.748	0.18

Estimation for Difference

Difference	95% CI for Difference
0.362	(-0.080, 0.804)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
1.68	27	0.104

Two-Sample T-Test: Question 4

Method

μ_1: mean of Q4 when Type = CL
μ_2: mean of Q4 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q4

Type	N	Mean	StDev	SE Mean
CL	19	2.95	1.22	0.28
QF	17	2.47	1.07	0.26

Estimation for Difference

Difference	95% CI for Difference
0.477	(-0.300, 1.254)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
1.25	33	0.221

Two-Sample T-Test: Question 5

Method

μ_1: mean of Q5 when Type = CL
μ_2: mean of Q5 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q5

Type	N	Mean	StDev	SE Mean
CL	19	4.74	1.15	0.26
QF	17	4.76	1.03	0.25

Estimation for Difference

Difference	95% CI for Difference
-0.028	(-0.767, 0.711)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.08	33	0.939

Two-Sample T-Test: Question 6

Method

μ_1: mean of Q6 when Type = CL
μ_2: mean of Q6 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q6

Type	N	Mean	StDev	SE Mean
CL	19	3.37	1.46	0.34
QF	17	3.41	1.28	0.31

Estimation for Difference

Difference	95% CI for Difference
-0.043	(-0.972, 0.885)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.09	33	0.925

Two-Sample T-Test: Question 7

Method

μ_1: mean of Q7 when Type = CL
μ_2: mean of Q7 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q7

Type	N	Mean	StDev	SE Mean
CL	19	4.68	1.42	0.32
QF	17	4.76	1.35	0.33

Estimation for Difference

Difference	95% CI for Difference
-0.080	(-1.018, 0.857)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.17	33	0.862

Two-Sample T-Test: Question 8

Method

μ_1: mean of Q8 when Type = CL
μ_2: mean of Q8 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q8

Type	N	Mean	StDev	SE Mean
CL	19	3.21	1.55	0.36

QF	17	3.18	1.63	0.40

Estimation for Difference

Difference	95% CI for Difference
0.034	(-1.047, 1.115)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
0.06	33	0.949

Two-Sample T-Test: Question 9

Method

μ_1: mean of Q9 when Type = CL
μ_2: mean of Q9 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q9

Type	N	Mean	StDev	SE Mean
CL	19	4.26	1.19	0.27
QF	17	4.882	0.857	0.21

Estimation for Difference

Difference	95% CI for Difference
-0.619	(-1.320, 0.082)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.80	32	0.081

Two-Sample T-Test: Question 10

Method

μ_1: mean of Q10 when Type = CL
μ_2: mean of Q10 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q10

Type	N	Mean	StDev	SE Mean
CL	19	2.53	1.39	0.32
QF	17	2.82	1.55	0.38

Estimation for Difference

Difference	95% CI for Difference
-0.297	(-1.301, 0.707)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.60	32	0.551

Two-Sample T-Test: Question 11

Method

μ_1: mean of Q11 when Type = CL
μ_2: mean of Q11 when Type = QF
Difference: $\mu_1 - \mu_2$

Equal variances are not assumed for this analysis.

Descriptive Statistics: Q11

Type	N	Mean	StDev	SE Mean
CL	19	4.58	1.12	0.26
QF	17	4.882	0.993	0.24

Estimation for Difference

Difference	95% CI for Difference
-0.303	(-1.020, 0.413)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.86	33	0.395

Two-Sample T-Test: Question 12

Method

μ_1: mean of Q12 when Type = CL
μ_2: mean of Q12 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q12

Type	N	Mean	StDev	SE Mean
CL	19	3.42	1.46	0.34
QF	17	3.88	1.22	0.30

Estimation for Difference

Difference	95% CI for Difference
-0.461	(-1.372, 0.449)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.03	33	0.310

Two-Sample T-Test: Question 13

Method

μ_1: mean of Q13 when Type = CL
μ_2: mean of Q13 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q13

Type	N	Mean	StDev	SE Mean
CL	19	4.53	1.22	0.28
QF	17	4.765	0.970	0.24

Estimation for Difference

Difference	95% CI for Difference
-0.238	(-0.982, 0.505)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.65	33	0.519

Two-Sample T-Test: Question 14

Method

μ_1: mean of Q14 when Type = CL
μ_2: mean of Q14 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q14

Type	N	Mean	StDev	SE Mean
CL	19	3.79	1.44	0.33
QF	17	4.294	0.920	0.22

Estimation for Difference

Difference	95% CI for Difference
-0.505	(-1.317, 0.308)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.27	30	0.215

Two-Sample T-Test: Question 15

Method

μ_1: mean of Q15 when Type = CL
μ_2: mean of Q15 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q15

Type	N	Mean	StDev	SE Mean
CL	19	4.00	1.45	0.33
QF	17	4.71	1.10	0.27

Estimation for Difference

Difference	95% CI for Difference
-0.706	(-1.576, 0.164)

Test

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.65	33	0.108

Two-Sample T-Test: Question 16

Method

μ_1: mean of Q16 when Type = CL
μ_2: mean of Q16 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: Q16

Type	N	Mean	StDev	SE Mean
CL	19	4.05	1.43	0.33
QF	17	4.647	0.996	0.24

Estimation for Difference

Difference	95% CI for Difference
-0.594	(-1.425, 0.237)

Test

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.46	32	0.155

Appendix D:

Mann-Whitney test, Six-point scale

Mann-Whitney: Question 1

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	6
QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(0.0000000, 2)	95.05%

Test

Null hypothesis H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	390.50	0.222
Adjusted for ties	390.50	0.197

Mann-Whitney: Question 2

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	3
QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-0.0000000, 1)	95.05%

Test

Null hypothesis H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	375.00	0.466
Adjusted for ties	375.00	0.447

Mann-Whitney: Question 3

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	2
QF	17	2

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(0.0000000, 1)	95.05%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	394.00	0.183
Adjusted for ties	394.00	0.138

Mann-Whitney: Question 4

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	3
QF	17	2

Estimation for Difference

Difference	CI for Difference	Achieved Confidence

0.0000000	(-0.0000000, 1)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	385.50	0.288
Adjusted for ties	385.50	0.266

Mann-Whitney: Question 5

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	5
QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-1, 1)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	353.00	0.975
Adjusted for ties	353.00	0.973

Mann-Whitney: Question 6

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	3

QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, 1)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	349.00	0.949
Adjusted for ties	349.00	0.948

Mann-Whitney: Question 7

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	5
QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-1, 1)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	348.50	0.937
Adjusted for ties	348.50	0.934

Mann-Whitney: Question 8

Method

η_1: median of CL
η_2: median of QF

Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	3
QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, 1)	95.05%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	354.00	0.949
Adjusted for ties	354.00	0.948

Mann-Whitney: Question 9

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	4
QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-1	(-1, -0.0000000)	95.05%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	304.00	0.136
Adjusted for ties	304.00	0.115

Mann-Whitney: Question 10

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	2
QF	17	2

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, 1)	95.05%

Test

Null hypothesis	$H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis	$H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	332.00	0.547
Adjusted for ties	332.00	0.526

Mann-Whitney: Question 11

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	5
QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-1, -0.0000000)	95.05%

Test

Null hypothesis	$H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis	$H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	327.50	0.456
Adjusted for ties	327.50	0.430

Mann-Whitney: Question 12

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	3
QF	17	4

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-1	(-2, 0.0000000)	95.05%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	319.00	0.311
Adjusted for ties	319.00	0.294

Mann-Whitney: Question 13

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	5
QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence

-0.0000000	(-1, -0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	342.50	0.788
Adjusted for ties	342.50	0.762

Mann-Whitney: Question 14

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	4
QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, -0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	327.00	0.447
Adjusted for ties	327.00	0.411

Mann-Whitney: Question 15

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	4

QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-1	(-1, -0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	307.00	0.163
Adjusted for ties	307.00	0.147

Mann-Whitney: Question 16

Method

η_1: median of CL
η_2: median of QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	5
QF	17	5

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, 0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	318.50	0.303
Adjusted for ties	318.50	0.275

Appendix E:

Two-sample t-test, Three-point scale

Two-Sample T-Test: Question 1

Method

μ_1: mean of R Q1 when Type = CL
μ_2: mean of R Q1 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q1

Type	N	Mean	StDev	SE Mean
CL	19	2.737	0.562	0.13
QF	17	2.471	0.624	0.15

Estimation for Difference

Difference	95% CI for Difference
0.266	(-0.139, 0.671)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
1.34	32	0.190

Two-Sample T-Test: Question 2

Method

μ_1: mean of R Q2 when Type = CL
μ_2: mean of R Q2 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q2

Type	N	Mean	StDev	SE Mean
CL	19	2.263	0.733	0.17
QF	17	2.059	0.827	0.20

Estimation for Difference

Difference	95% CI for Difference
0.204	(-0.329, 0.738)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$

Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
0.78	32	0.441

Two-Sample T-Test: Question 3

Method

μ_1: mean of R Q3 when Type = CL
μ_2: mean of R Q3 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q3

Type	N	Mean	StDev	SE Mean
CL	19	1.421	0.507	0.12
QF	17	1.294	0.470	0.11

Estimation for Difference

Difference	95% CI for Difference
0.127	(-0.204, 0.458)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
0.78	33	0.441

Two-Sample T-Test: Question 4

Method

μ_1: mean of R Q4 when Type = CL
μ_2: mean of R Q4 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q4

Type	N	Mean	StDev	SE Mean
CL	19	1.842	0.898	0.21
QF	17	1.647	0.862	0.21

Estimation for Difference

Difference	95% CI for Difference

0.195	(-0.402, 0.792)

Test

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
0.66	33	0.511

Two-Sample T-Test: Question 5

Method

μ_1: mean of R Q5 when Type = CL
μ_2: mean of R Q5 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q5

Type	N	Mean	StDev	SE Mean
CL	19	2.632	0.597	0.14
QF	17	2.588	0.618	0.15

Estimation for Difference

Difference	95% CI for Difference
0.043	(-0.370, 0.457)

Test

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
0.21	33	0.832

Two-Sample T-Test: Question 6

Method

μ_1: mean of R Q6 when Type = CL
μ_2: mean of R Q6 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q6

Type	N	Mean	StDev	SE Mean
CL	19	1.947	0.780	0.18
QF	17	1.941	0.827	0.20

Estimation for Difference

Difference	95% CI for Difference
0.006	(-0.541, 0.553)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
0.02	33	0.982

Two-Sample T-Test: Question 7

Method

μ_1: mean of R Q7 when Type = CL
μ_2: mean of R Q7 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q7

Type	N	Mean	StDev	SE Mean
CL	19	2.579	0.692	0.16
QF	17	2.588	0.618	0.15

Estimation for Difference

Difference	95% CI for Difference
-0.009	(-0.454, 0.435)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.04	33	0.966

Two-Sample T-Test: Question 8

Method

μ_1: mean of R Q8 when Type = CL
μ_2: mean of R Q8 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q8

Type	N	Mean	StDev	SE Mean
CL	19	1.789	0.855	0.20
QF	17	1.765	0.752	0.18

Estimation for Difference

Difference	95% CI for Difference
0.025	(-0.520, 0.570)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
0.09	33	0.927

Two-Sample T-Test: Question 9

Method

μ_1: mean of R Q9 when Type = CL
μ_2: mean of R Q9 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q9

Type	N	Mean	StDev	SE Mean
CL	19	2.316	0.749	0.17
QF	17	2.706	0.470	0.11

Estimation for Difference

Difference	95% CI for Difference
-0.390	(-0.811, 0.031)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.89	30	0.068

Two-Sample T-Test: Question 10

Method

μ_1: mean of R Q10 when Type = CL
μ_2: mean of R Q10 when Type = QF

Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q10

Type	N	Mean	StDev	SE Mean
CL	19	1.474	0.772	0.18

QF 17 1.588 0.712 0.17

Estimation for Difference

Difference	95% CI for Difference
-0.115	(-0.618, 0.389)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.46	33	0.646

Two-Sample T-Test: Question 11

Method

μ_1: mean of R Q11 when Type = CL
μ_2: mean of R Q11 when Type = QF
Difference: $\mu_1 - \mu_2$

Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q11

Type	N	Mean	StDev	SE Mean
CL	19	2.526	0.697	0.16
QF	17	2.706	0.470	0.11

Estimation for Difference

Difference	95% CI for Difference
-0.180	(-0.580, 0.221)

Test

Null hypothesis $H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis $H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.91	31	0.367

Two-Sample T-Test: Question 12

Method

μ_1: mean of R Q12 when Type = CL
μ_2: mean of R Q12 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q12

Type	N	Mean	StDev	SE Mean
CL	19	1.842	0.834	0.19
QF	17	2.176	0.728	0.18

Estimation for Difference

Difference	95% CI for Difference
-0.334	(-0.864, 0.195)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.28	33	0.208

Two-Sample T-Test: Question 13

Method

μ_1: mean of R Q13 when Type = CL
μ_2: mean of R Q13 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q13

Type	N	Mean	StDev	SE Mean
CL	19	2.579	0.769	0.18
QF	17	2.647	0.606	0.15

Estimation for Difference

Difference	95% CI for Difference
-0.068	(-0.535, 0.399)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$

Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.30	33	0.769

Two-Sample T-Test: Question 14

Method

μ_1: mean of R Q14 when Type = CL
μ_2: mean of R Q14 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q14

Type	N	Mean	StDev	SE Mean
CL	19	2.158	0.898	0.21
QF	17	2.471	0.624	0.15

Estimation for Difference

Difference	95% CI for Difference
-0.313	(-0.834, 0.208)

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.22	32	0.230

Two-Sample T-Test: Question 15

Method

μ_1: mean of R Q15 when Type = CL
μ_2: mean of R Q15 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q15

Type	N	Mean	StDev	SE Mean
CL	19	2.263	0.806	0.18
QF	17	2.588	0.618	0.15

Estimation for Difference

Difference	95% CI for Difference

-0.325	(-0.809, 0.159)

Test

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-1.37	33	0.181

Two-Sample T-Test: Question 16

Method

μ_1: mean of R Q16 when Type = CL
μ_2: mean of R Q16 when Type = QF
Difference: $\mu_1 - \mu_2$
Equal variances are not assumed for this analysis.

Descriptive Statistics: R Q16

Type	N	Mean	StDev	SE Mean
CL	19	2.368	0.761	0.17
QF	17	2.529	0.624	0.15

Estimation for Difference

Difference	95% CI for Difference
-0.161	(-0.631, 0.309)

Test

Null hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative hypothesis	$H_1: \mu_1 - \mu_2 \neq 0$

T-Value	DF	P-Value
-0.70	33	0.491

Appendix F:

Mann-Whitney test, Three-point scale

Mann-Whitney: Question 1

Method

η_1: median of CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
CL	19	3
R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-0.0000000, 1)	95.05%

Test

Null hypothesis H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	391.50	0.211
Adjusted for ties	391.50	0.130

Mann-Whitney: Question 2

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	2
R QF	17	2

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(0.0000000, 1)	95.05%

Test

Null hypothesis H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	373.50	0.496
Adjusted for ties	373.50	0.466

Mann-Whitney: Question 3

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	1
R QF	17	1

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-0.0000000, 0.0000000)	95.05%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	372.00	0.526
Adjusted for ties	372.00	0.446

Mann-Whitney: Question 4

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	2
R QF	17	1

Estimation for Difference

Difference	CI for Difference	Achieved Confidence

0.0000000	(-0.0000000, 1)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	371.00	0.547
Adjusted for ties	371.00	0.507

Mann-Whitney: Question 5

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	3
R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-0.0000000, 0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	357.50	0.862
Adjusted for ties	357.50	0.833

Mann-Whitney: Question 6

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	2

R QF	17	2

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, 1)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	352.50	0.987
Adjusted for ties	352.50	0.987

Mann-Whitney: Question 7

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	3
R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(0.0000000, -0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	354.50	0.937
Adjusted for ties	354.50	0.924

Mann-Whitney: Question 8

Method

η_1: median of R CL
η_2: median of R QF

Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	2
R QF	17	2

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-1, 1)	95.05%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	351.50	1.000
Adjusted for ties	351.50	1.000

Mann-Whitney: Question 9

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	2
R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, -0.0000000)	95.05%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	306.50	0.159
Adjusted for ties	306.50	0.107

Mann-Whitney: Question 10

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	1
R QF	17	1

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, 0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	332.50	0.558
Adjusted for ties	332.50	0.500

Mann-Whitney: Question 11

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	3
R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(0.0000000, 0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	334.50	0.601
Adjusted for ties	334.50	0.527

Mann-Whitney: Question 12

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	2
R QF	17	2

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-1, -0.0000000)	95.05%

Test

Null hypothesis $H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis $H_1: \eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	314.00	0.241
Adjusted for ties	314.00	0.213

Mann-Whitney: Question 13

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	3
R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence

-0.0000000	(-0.0000000, 0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	351.50	1.000
Adjusted for ties	351.50	1.000

Mann-Whitney: Question 14

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	2
R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-1, 0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	323.50	0.384
Adjusted for ties	323.50	0.342

Mann-Whitney: Question 15

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	2

R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
-0.0000000	(-1, 0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	316.50	0.274
Adjusted for ties	316.50	0.221

Mann-Whitney: Question 16

Method

η_1: median of R CL
η_2: median of R QF
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
R CL	19	3
R QF	17	3

Estimation for Difference

Difference	CI for Difference	Achieved Confidence
0.0000000	(-1, -0.0000000)	95.05%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 \neq 0$

Method	W-Value	P-Value
Not adjusted for ties	335.50	0.623
Adjusted for ties	335.50	0.581